The Brattle Group

Reforming Renewable Support in the United States

Lessons from National and International Experience

November 1, 2012

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This report was prepared for the Bipartisan Policy Center.

Jürgen Weiss and Pedro Marin are Principals of *The Brattle Group*. All results and any errors are the responsibility of the authors and do not represent the opinion of *The Brattle Group*.

ACKNOWLEDGEMENTS

We acknowledge the valuable contributions of many individuals to this report and to the underlying analysis, including Dean Murphy and Mark Sarro of *The Brattle Group* for peer review.

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I. EXECUTIVE SUMMARY

The Bipartisan Policy Center ("BPC") asked *the Brattle Group* to evaluate the domestic and international experience with renewable energy support systems with the goal of drawing lessons for potential reforms of US federal renewable energy support. In this report, we present the results of our findings.

There is relatively broad agreement that some form of support for emerging renewable technologies is justified. There is however a relatively wide range of opinions with respect to the appropriate form such support might take and, consequently, a wide range of approaches is being used both in the US and abroad.

In particular, there is some evidence that suggests that U.S. federal support for renewable energy, while considered an important complement to state-level efforts, could be significantly improved. At present, federal support involves a mix of R&D support mechanisms, various types of advantageous tax treatments, in particular in the form of an accelerated depreciation allowance as well as the production tax credit ("PTC") and investment tax credit ("ITC"), and, until recently, various forms of loan guarantees under Section 1703 and 1705 of the Energy Policy Act of 2005 and cash grants (in lieu of the ITC/PTC) under Section 1603 of the American Recovery and Reinvestment Act ("ARRA").

There is evidence both of the importance of the ITC/PTC for renewable energy development and the problems associated with it. Most importantly, both require frequent reauthorization by Congress and this reauthorization has failed to materialize on several occasions in the past. Each time this failure has resulted in a drying-up of investment in renewable energy projects in the face of the risk that the ITC/PTC would not be available by the time projects are eligible to participate.

The efficiency of loan guarantees has also been hotly debated. In particular, even though it is likely that the loan guarantee program has helped secure financing for a significant number of renewable energy projects, questions have been raised about whether or not government is well qualified to choose likely winners by investing in particular projects or companies.

Support for renewable (and perhaps other low carbon) technologies is generally motived by several considerations. In order of decreasing consensus amongst economists, they are 1) the desire to address environmental externalities, most notably concerns about greenhouse gases leading to substantial climate change related risks; 2) the perceived need to help emerging renewable technologies overcome certain barriers to development; 3) the hope that support for renewable energy will help develop new technologies and subsequently create new jobs and/or economic activity and 4) energy security.

The theoretical argument for supporting renewable energy production to deal with various forms of externalities associated with electricity production from fossil fuels is relatively strong. If environmental externalities were the only motivation for renewable energy support, direct pricing of the respective externalities, by using emissions taxes or quantity limits such as cap-and-trade approaches, would be the theoretically preferred option. However, there is substantial evidence that beyond environmental externalities, there are also externalities related to the creation of knowledge in alternative young and emerging technologies designed to solve the same problem under different technological constraints, including several key renewable technologies such as wind and solar, as well as even newer technologies such as various forms of ocean-based electricity generation. The combination of both environmental externalities and knowledge spill-overs creates a solid argument for support mechanisms that go beyond the pricing of environmental externalities alone, including R&D support, but also direct support for electricity generation from specific renewable technologies.

The case for job creation and energy security is somewhat less straightforward. Energy security concerns are likely real, but to the extent they represent an externality justify the support of a broad set of energy sources including renewables, but also natural gas, oil and coal production.

The argument that renewable energy creates additional jobs is complex and not fully explored in this paper. The complexity stems from the fact that while investment in renewable energy projects will certainly create jobs, mostly related to the construction of renewable energy plants and infrastructures, and to a lesser extent to the maintenance of renewable energy facilities, such job gains have to be weighed against potential job losses in other parts of the economy if renewable energy support increases the cost of electricity. Existing economic models have severe limitations when it comes to analyzing the net effect. Among other things, they tend to assume an "efficient" macro-economy and often full employment. With full employment, additional job creation is by definition difficult. An efficient economy also leaves little room for the creation of new and successful industry clusters through government policy. In reality, the macro-economy is likely not fully efficient (and certainly not characterized by full employment at all times). Research on how inefficiencies might be cured through targeted government intervention, for example helping the creation of new and emerging industries as clusters, is ongoing and so far provides some suggestions for "good policy", but is hardly conclusive.

Nonetheless, in sum the theoretical argument for government intervention of some kind to support the development of renewable energy sources is strong. Having established the basic rationale for supporting the development of renewable energy, this report focuses on the identification, based on national and international experience, of key policy elements that are most successful, both in terms of getting renewable energy capacity built and in doing so efficiently.

To derive such policy measures, we closely examined two domestic and two international cases: California, Massachusetts, Germany and the United Kingdom. We chose these four case studies to closely examine both very successful examples of renewable energy deployment (California, Germany) and examples of policy frameworks that have adapted and changed significantly over time in response to early difficulties (Massachusetts, United Kingdom).

California and Germany have made significant strides towards expanding renewable energy. Both now meet in excess of 20% of total electricity demand from renewable sources, and both are on track to exceeding 30% of demand with renewable generation sources by 2020. Both share two key features of electricity support

- Renewable energy projects enjoy a relatively high degree of revenue certainty. In the case of California, this certainty stems from either long-term contracts for energy, capacity and renewable energy attributes (larger projects) or a feed-in tariff ("FIT") or net metering (small scale distributed renewables). In the case of Germany, the primary mechanism to ensure revenue stability is through FITs.
- Support for renewable energy is at least somewhat differentiated by technology. In Germany, each technology is subject to a different FIT, making the technology distinction very explicit. In California, certain support only applies to certain technologies (PV), but indirectly support has also been technology specific, namely through the signing of long-term contracts at different price levels for different technologies.

The same two key insights also emerge from our case studies of Massachusetts and the United Kingdom. Both initially relied on certificates approaches – a Renewable Portfolio Standard ("RPS") with tradable certificates in the case of Massachusetts, a Renewables Obligation also with tradable certificates in the case of the UK – and both struggled initially in ramping up renewables deployment. Recognizing that changes were needed both embarked on a series of reforms that over time have moved towards technology-specific long-term revenue support. In Massachusetts, this involved moving towards using long-term contracting for renewable power, the requirement for which was recently doubled from 3% to 6% of total demand. The 6% requirement represents most of the current renewable requirements, given the current level of RPS targets, but will represent a smaller share of the total requirement going forward as the total RPS target increases to 15% by 2020. In the United Kingdom, the move has been by providing a different number of renewable obligation certificates ("ROCs") to each technology, as a still ongoing effort to move to a system of technology-specific feed-in tariffs.

One additional theme emerged specifically from the European case studies, namely the importance of public lending support in particular in the early phase of renewable energy development, or in areas where individual projects are large. Various public lenders in Europe, in particular the European Investment Bank ("EIB") and the Kreditanstalt für Wiederaufbau ("KfW") in Germany, have played a vital role in facilitating the development of wind and solar technologies and are currently playing a significant role in the development of very capital intensive large scale offshore wind projects in both Germany and the United Kingdom.

While not being picked up in our state-level case studies in the United States, the success of the federal loan guarantee program, at least in terms of facilitating the financing of renewable projects, suggests that financing support from public entities has also been critical in the United States. However, a potential key difference between European and US efforts has been the fact that European infrastructure and development banks function essentially independently from governments and government budget allocations, which has not been the case in the United States. The consequence has been the familiar "boom-bust" problem in the United States, where financing support, subject to relatively short-term political developments, remains relatively uncertain, likely creating significant risks (and higher costs) for renewable project development.

We therefore conclude that there is not only a rationale for continued support of renewable energy in the United States, but that there is substantial room for improvement of current federal policies targeting renewable energy. We suggest several key lessons both from international and state-level experience.

First, long-term predictability and stability of the policy and regulatory framework supporting renewable energy is important. In the past, the fact that US federal energy support was based on relatively short term incentives, which have to be regularly reauthorized by Congress, has likely hampered the development of renewable energy and increased its cost. Successful policies, by contrast, provide long-term policy support that is not subject to short-term revisions as a result of changes in the composition of government. This is important because of the development cycle and the time to recuperate initial investments in renewable energy projects is long. Policy certainty over just a few years therefore increases project risks significantly.

Second, also due to the special characteristics of most renewable energy projects, namely the fact that upfront capital investments represent by far the largest portion of total project costs, providing relatively long-term revenue stability for such projects, of the order of 15-20 years, is critical for facilitating the financing of such projects. In this context, certificate schemes such as those that would result from a federal Clean Energy or Renewable Energy Standard have generally proven less effective than price guarantees, either in the form of long-term contracts or feed-in tariffs.

Third, even though technology neutrality is an appealing concept, evidence from successful efforts to support renewable energy development as well as economic theory on market imperfections related to the creation and dissemination of knowledge suggests that some amount of technology-specific support will be required in order to allow newer, less developed technologies to compete with more established technologies, even if this results in an initially higher effort. The fact that a relatively high proportion of loan guarantees in the United States have recently gone to solar projects suggests that current or recent federal policy at least implicitly acknowledges this necessity. National and international experience reflects the same necessity either through technology-specific feed-in tariffs or through long-term contracting with different technologies at different price points, or through a differentiation within renewable portfolio standards by technology.

Finally, evidence from Europe suggests that especially for immature technologies or for large and capital intensive projects for technologies that are not fully mature some sort of support related to the actual financing of a given project may be needed to attract sufficient private capital. The role of public infrastructure lending in Europe, while not discussed as much as direct revenue support, was and is large. Similarly, the U.S. Department of Energy ("DOE") loan guarantee programs have likely been an important enabler of financing recent large-scale renewable energy projects. Since US development of several renewable technologies such as solar PV and CSP and offshore wind lags significantly behind corresponding developments in

Europe and since Europe still relies substantially on public infrastructure banking support for these technologies, it is likely that some form of lending support will be important in scaling up project development for those technologies in the US.

Evidence from both the successful US states and European countries suggests that careful reforms of renewable energy support at the federal level along the lines discussed above and in greater detail below could significantly increase the efficacy and cost-effectiveness of such support and, by doing so, create broader support for such policies.

II. INTRODUCTION

The threat of harm caused from human-induced climate change, concerns about the political stability of the source countries for much of the energy currently used by the world and the perceived need – and the opportunity - to leverage (or develop) highly skilled work forces to create the next generation of local industries are three of the main reasons why it is believed that renewable energy technologies will play a critical and increasing role in the future, in the United States and globally.

40 years after the first oil shock of 1973, technological efforts to improve energy efficiency have proven successful in many respects and, as a result, energy intensity has fallen substantially but, at the same time, world demand has grown steadily and energy supply is still completely dominated by fossil fuels, namely oil, natural gas and coal. This suggests that in particular to respond to the climate change threat, the speed of deployment of alternatives to the current energy supply mix will have to be significantly accelerated.

Fortunately, over the 40 years since the first oil shock of 1973 a lot of progress has been made with respect to both the technological readiness of alternatives and with respect to approaches to fostering those technologies through the use of targeted government policies.

This paper is designed to provide a synthesis of the learning about the "why" and the "how" of government support for renewable energy[1]. It relies on a small but deliberately chosen set of case studies from the United States and Europe to identify key elements of successful – in the sense of promoting the deployment of renewable energy sources and of doing so relatively cost-effectively – and failed government support for renewable energy. The main purpose of this report is therefore to identify and propose key elements of such support policy that, based on the domestic and international experience, are likely to be more efficient than current federal support systems for renewable energy.

The timing of this paper is deliberate as well. Unfortunately not for the first time, the United States faces the real possibility that the main pillars of federal support for renewable energy, the system of production tax credits ("PTC") and investment tax credits ("ITC") will not be

[1] There are other means of addressing environmental externalities in the energy sector, notably through energy efficiency, carbon capture and sequestration, and the development of other no- or low-fossil technologies in the electricity and transport sector, the analysis of which is beyond the scope of this report.

extended. Historically, the importance of both PTC and ITC is evidenced by the pattern of investment in renewable energy around similar past threats of non-extension of both programs. In particular, delays in the reauthorization process on several occasions in the past has resulted in a drying up of investment in renewable energy projects[2] in the face of the risk that the ITC/PTC would not be available by the time projects are eligible to participate[3].

The times around uncertain renewal of the programs thus seem opportune moments to examine possible ways in which the US approach to renewable energy support might be fundamentally reformed in ways that benefit from the close to 40 years of experience.

To do so, this paper proceeds in three steps. First, we briefly review the rationale for renewable energy support. In this section, we aim to lay out the main themes in a pragmatic fashion rather than strive for academic precision. Ultimately, the economic arguments for and against direct support for renewable energy are complex and there is at present no unanimous agreement as to whether the pros or the cons are winning out. We believe nonetheless that is it useful to understand the complexities involved in a number of areas.

Second, we examine the experience with renewable energy support in a number of states and countries, focusing each time on important lessons that might be learned from each experience.

In the final section of this white paper we attempt to extract from the case studies a small number of elements we believe have emerged as important pillars of successful renewable energy support programs. These pillars could serve to design a more effective US federal renewable support policy going forward, meaning that the same federal dollars spent could stimulate significant additional renewable energy development or the current levels of renewable development could be achieved at a lower cost to tax payers.

III. THE RATIONALE FOR RENEWABLE ENERGY SUPPORT

Support for renewable energy exists in many parts of the world. In this section, we briefly highlight the core arguments for government support for the development of renewable energy sources since, without a legitimate rationale, there would be no reason to have and to reform renewable energy policy in the United States.

As a very general matter, the economic argument in favor of potential government intervention in any market rests on the question of whether or not markets, left to their own

2 For an analysis of the impact of lapsing PTC, see Ryan Wiser, Mark Bolinger, and Galen Barbose, Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States, LBNL-63583, November 2007

3 For a discussion of the historic and potential future impact of the PTC on wind development, see Phillip Brown, U.S. Renewable Electricity: How Does the Production Tax Credit (PTC) Impact Wind Markets? Congressional Research Service, June 20, 2012. For a more in-depth discussion of historic federal tax measures to support energy investments, see Molly Sherlock, Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures, Congressional Research Service, May 7, 2010.

devices, would come up with solutions that are optimal for society, or at least better than anything government might attempt to do. In economics language, government action may be justified in the presence of any number of "market failures".

Below we outline several such market failures that provide at least a theoretical justification for government support of renewable energy. Even if the theoretical case for government intervention can be made, whether or not actual government intervention is desirable depends significantly on the efficiency and efficacy of the government intervention itself, which in turn depends crucially on the details of the form and implementation of the intervention.

In the remainder of this section, we lay out the key reasons for government support for renewable energy. We begin with a discussion of the environmental externality argument; next, we describe various issues related to knowledge externalities associated with emerging technologies, which may justify subsidies at early stages of development and finally discuss whether or not, as a result of such knowledge externalities, direct support for renewable technologies may be "optimal" from society's perspective, or whether it will remain "second best" to alternative approaches such as the direct pricing of environmental externalities.

Clearly, our explanation of the rationale for renewable energy support here is not new. For example, the European Commission, in a recent report, stated the rationale for renewable energy support as follows:

> "The RES Directive is based on the rationale that a positive framework for renewable energy development is necessary due to a number of market and regulatory failures or imperfections. These include non-internalisation of negative externalities of conventional energy forms, the presence of subsidies for other energy forms, imperfect market structures, regulatory barriers, the status of many renewable technologies as "infant industries" together with significant inertia of the system, and barriers related to information and public perception.[4]"

For our discussion throughout, it is important to distinguish between "support" and "subsidy". We will use "support" to mean any type of aid that is financed by energy consumers themselves, either all energy users or a subset (electricity, energy applied for mobility, etc.), whereas we will use the term "subsidy" to indicate aid that is financed by a broader group, typically tax payers. The distinction is important because subsidies will tend to lower prices and thus lead to incentives for increased consumption, an incentive that goes counter the socially optimal outcome when negative environmental externalities are at the heart of the issue and as long as fossil sources are supplying some of the incremental consumption.[5] However, to the extent that renewable technologies also have resulted in positive externalities along the lines mentioned above (lower dependency on foreign and unreliable energy

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[4] Commission Staff Working Paper SWD (2012) 149 Final; Impact Assessment accompanying the document *Renewable energy: a major player in the European energy market; p.12.*

[5] For an in-depth discussion of the problems associated with subsidies rather than direct externality pricing, see Gilbert Metcalf, *Tax Policies for Low-Carbon Technologies*, September 2009.

sources,[6] technological development, job creation, etc.), it could be reasonable to distribute part of their costs beyond energy consumers. Moreover, in a world where energy prices are subject to substantial country-specific subsidies and taxes, energy prices significantly above international competitive standards may threaten economic competitiveness[7].

A. Government Intervention to cure environmental externalities

Addressing externalities has long been recognized as a key area of government intervention. In the presence of a negative externality, markets, left to their own devices, will not lead to socially optimal outcomes[8]. There is a rich history in economic thought about ways to cure this market failure.

The most prominent examples of negative externalities are various forms of pollution caused by economic activity. In the absence of a full set of property rights – i.e. people don't "own the air" – there will be too much production from pollution-creating economic activities.

The standard economic response to pollution externalities is to "internalize" the externality. In practical terms, this means creating a property right over the pollutant and assigning it to somebody. The two market-based approaches most widely used are to use a set of Pigouvian taxes or some kind of cap and trade scheme.

Pigouvian taxes, proposed by British economist Arthur C. Pigou, impose a tax on the polluting activity – they set a price on pollution. Once facing a positive cost (since prior to the imposition of the tax the cost to polluters was zero) of pollution, consumption and production will fall (the price will rise, but not enough to compensate producers, and due to demand and supply elasticities consumers will demand less and producers will sell less), leading to lower pollution levels. Possible examples of Pigouvian taxes are carbon taxes, proposed taxes on fat or sodas, and perhaps gasoline, tobacco and alcohol taxes.

An alternative to taxing the polluting activity is to impose caps on total pollutant levels, either for each producer or for the economy overall. In the latter case, an economy- or industry-wide cap is typically combined with a tradable permit system – resulting in a cap-and-trade system, in which each permit corresponds to a unit of pollution and polluters can buy and sell permits to each other. Examples of cap-and-trade systems are the European Union Emissions Trading Scheme ("EU ETS") for greenhouse gas ("GHG'') emissions, the sulfur dioxide program

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6 We do not address energy security here, as it equally applies to the support of other domestic sources of supply, or the support of resources from "friendly" trading partners. Nonetheless, given that many countries do not have domestic fossil fuel sources, the development of renewable energy may be the only means of accomplishing a desired degree of energy security.

7 Concern about this is perhaps highlighted best by the recent developments in Germany, where the government announced that the timing of the move away from fossil and nuclear fuels had to be revisited in the light of keeping electricity "affordable" (based on article *Regierung weicht Energieziele auf*, downloaded from www.spiegel.de on July 17, 2012)

8 See for example Molly Sherlock, Donald Marples, Energy Tax Policy: Issues in the 111th Congress, Congressional Research Service, June 16, 2010, pages 2-6 for a recent explanation of the externality rationale in the context of current U.S. tax policy.

under the United States Clean Air Act (‘‘CAA’’), or the Regional Greenhouse Gas Initiative (“RGGI”). As with Pigouvian taxes, the idea behind a cap-and-trade system is to put a price/cost on pollution. However, unlike a tax, which is set by government directly, the cost of pollution under a cap-and-trade system is determined by the permit price, which in turn results from willing buyers and sellers exchanging permits in the market and which depends on the level of the cap and the cost of lowering emissions throughout the sectors under the cap. If the cap on pollution is significantly below current pollution levels, it is likely that the resulting permit prices will be higher, making pollution activities costlier and hence creating an incentive to reduce polluting activities.

In sum, both tax and cap-and-trade approaches make polluting costly and hence create an incentive to pollute less. The basic intuition is simple: internalizing the costs associated to the negative externality leads to higher prices, which reduce demand and hence result in less production of the negative externality[9].

Depending on the approach, support for renewable energy can have an effect on energy prices similar to the one that results from a cap-and-trade or tax approach. In particular, if the support is financed through charges embedded in energy prices, renewable support programs will likely increase the price of all or some types of energy on average. As we will see below, however, renewable energy may be funded by subsidies financed by tax payers. Subsidies will typically have the effect of lowering the price of energy relative to the alternative of no support system for renewable energy. Since most renewable aid systems represent a mix of both measures, the net impact on energy prices is ambiguous.

Also, direct renewable support tends to be more technology specific than a tax or cap-and-trade approach. Feed-in tariffs (“FIT”) in particular, which at present represent the dominant form of renewable energy support, tend to be differentiated by technology. Tradable certificate schemes such as those created by Renewable Portfolio Standards (“RPS”) in the United States and by the Renewable Obligation (“RO”) in the United Kingdom (and discussed in detail below) can but do not have to be technology specific beyond typically applying to a subset of potential technologies only.

We next turn to a discussion of reasons other than environmental externalities that may be a basis for direct renewable energy support in addition or instead of using a cap-and-trade or tax, and which may also provide a basis for further differentiating support by technology within renewable energies.

B. Other types of externalities

Besides the pollution externality, which is ideally addressed through either a Pigouvian tax or a cap-and-trade system, but for which a set of support instruments for renewable energy may be a second-best alternative, the existence of additional externalities may also justify the use

9 For a more in-depth discussion of taxes versus cap-and-trade, see Jane Leggett, Climate Change: Current Issues and Policy Tools, CRS Report RL34513, March 6, 2009

of direct renewable energy support structures such as renewable portfolio standards, feed-in tariffs, or the tax credit instruments currently used in the United States.

Knowledge Spill-overs

The most prominent among the externalities typically discussed in the context of renewable energy support is the existence of information externalities. Many renewable technologies are still experiencing relatively rapid declines in cost due to continued advances in technology. In theory, a private investor should be willing to invest in an early-stage technology so that a process of learning and related cost reductions over time makes the technology cost-competitive with competing and established technologies. In practice, however, the learning that takes place as technology matures is almost never "private" – that is, others can learn from observing the progress and can offer cheaper products without having first invested at an earlier stage. This is often referred to as a "knowledge spill-over[10]" and leads to underinvestment in nascent technologies, even if at maturity those technologies might be capable of producing power at a lower cost than established and mature technologies.

In many markets, private investment still takes place, even in the presence of some spill-overs. The primary reason for this is that higher costs at the early stage of a technology's life can be recovered through higher prices in niche markets. The newest type of smart phone tends to be expensive in part because it uses technology that is at the early stage of development and hence has not yet benefited from the cost reductions that come with learning. However, the sellers of such smart phones can charge a high price to early technology adopters, mostly because the devices also offer features that differentiate them from existing products. It is difficult for renewable energy providers to benefit from product differentiation since the end product, electricity, is indistinguishable from electricity generated by more mature power generation technologies once it is fed into the power grid[11].

If a commodity such as electricity is produced through a variety of technologies, technologies with higher current costs will have a hard time competing even if, in a mature state of technological development, they may be cheaper than other technologies, at least in some specific markets. This is true for electricity generation in general, but also for the subset of renewable technologies. In theory, a carbon price could overcome the cost disadvantage of renewable technologies. However, a carbon price, whether in the form of a carbon tax or the permit price in a cap-and-trade system, will not address this problem as it exists among renewable technologies. In other words, in a world with a single carbon price signal, established renewable technologies will tend to dominate new and/or emerging technologies,

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10 See for example IEA, *Interactions of Policies for Renewable Energy and Climate*, 2011, page 11ff, which outlines the general argument why multiple policies including technology specific incentives may be optimal. It in turn cites Fischer, C. and R.G. Newell, *Environmental and Technology Policies for Climate Mitigation*, Journal of Environmental Economics and Management, Vol. 55, 2008, pp. 143-162. For a somewhat more skeptical view on the role of knowledge spill-overs, see Severin Borenstein, *The Private and Public Economics of Renewable Electricity Generation*, EI @ Haas WP 221R, December 2011, pages 18-19, and Kenneth Gillingham and James Sweeney, *Barriers to Implementing Low Carbon Technologies*, February 2012, page 8 and page 23.

11 It should be mentioned that selling "green power" at a premium has been an attempt at differentiation. However, enrollment in green power purchasing schemes is generally relatively modest.

even if they are not the most efficient solution in all markets and over time. Absent some other mechanism to overcome the knowledge spill-over problem, ultimately greenhouse gas reductions would be more costly than if the currently young but ultimately potentially most cost-effective technology were somehow encouraged to develop.

These considerations are of particular importance in the renewable energy industry, which by its intrinsic characteristics can highly benefit from a technological strategy of product proliferation. A proliferation strategy is characterized by simultaneous investment in several apparently competing technologies, while an escalation strategy implies concentrating all the efforts in a single dominant technological trajectory. Proliferation strategies are recommended when alternative technologies suffer from a low degree of demand substitution and little economies of scope. This means that none of the alternatives may easily meet all the demand requirements and more knowledge of one technology does not help advance another technology.[12] This is clearly the case of renewable technologies, since demand for one technology depends drastically on resource availability – how much and where the wind blows - and different technologies are characterized by very different physical and chemical processes. Given that alternative renewable technologies are at different technological stages and there is potential interest in all of them, there is a rationale for technology-specific support in order to allow newer, less developed technologies to develop alongside more established technologies even if this results in an initially higher cost.

There are several means that have been proposed and are employed to overcome the knowledge spill-over problem. We will discuss some of them in our case studies below, but list a few here. They include targeted R&D support, capital grants for pilot and demonstration projects, technology specific quota systems, technology specific tax-advantages, and technology-specific feed-in tariffs.

A related issue has to do with portfolio diversification in an uncertain world. In a commodity market such as the market for electricity, the currently cheapest technology tends to dominate. At present, in the United States, gas-fired combined cycle power plants (and perhaps gas turbines) dominate the market based on cost, given low gas prices. This is already leading to concerns about lack of resource diversity[13]. The concern stems from the fact that the future is unpredictable, and that technology lock-in may lead to higher costs in the long run. In the case of the current case of natural gas plants dominating new entry, the concern is over the possibility that future gas prices may rise and make other options more desirable, ex-post. The equivalent argument for developing a broad portfolio of renewable technologies rather than counting on the currently cheapest one is that at present there is much uncertainty about the cost of producing power from a variety of renewable technologies once those technologies reach maturity. In theory and based on observed historic trends, many of the technologies under consideration will likely benefit from further significant cost reductions (if deployed in significant quantities). However, it is unclear whether there will be clear winners and losers. It

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[12] For a more detailed analysis of alternative R&D strategies, see Sutton J., 1998, *Technology and market Structure. Theory and History*, MIT Press.

[13] See for example Mark Barbula, *Assessment of New England's Natural Gas System to Satisfy Short- and Near-term Power Generation Needs*, ISO New England, March 2012

can therefore be argued that there are benefits to supporting the development of a variety of technologies until some point at which those technologies are mature enough either for private investors to take on the risk of continued development (because the remaining learning and related knowledge spill-over is relatively small) or that it becomes clear that a certain technology will be dominated by others[14]. While support of a broad set of technologies may be appropriate in a global sense, it is likely that individual countries/regions will find it optimal to support only the subset of technologies that has the potential to become cost effective in that country or region[15].

Incomplete Markets
A second important market failure that may justify more direct support of renewables has to do with the absence of complete markets and the resulting impact on the financing of very capital intensive projects. In its extreme form, economists have a vision of markets that would seem rather ridiculous for non-economists. In particular, for markets to work perfectly, in addition to the requirements already hinted to above (no externalities), it is necessary for there to exist markets for every possible state of the world, today and in the future. Concretely, it would require that for electricity there are insurance mechanisms for every conceivable future event and period. For instance, it would need to be possible today to lock in a price for buying or selling power in 2020, 2030, 2050, etc. Furthermore, there would need to be a competitive price, meaning that there would be many potential buyers and sellers, many potential transactions, and hence anybody could buy (or sell) power for any future year with confidence that those prices reflect and incorporate all the publically available information that might impact them. In such a world, the developer of a renewable power project requiring a large upfront capital investment could contract for the sale of the power ultimately produced from the project for any number of years into the future and, thus, significantly reduce the uncertainty over revenues ultimately received once the project is built. With this certainty over revenue streams, the project developer could then approach lenders, who should be willing to lend money to the project, given that revenue related risks have been greatly reduced[16].

However, in the real world many of the futures (or forward) markets needed to lock-in the future revenues from a renewable power project either do not exist or are thin, meaning that there are only very few potential buyers and/or sellers and hence the risk of the price not reflecting all relevant information is high. Consequently, renewable project developers find it difficult to impossible to lock in revenues (or at least prices) beyond only a relatively short period into the future. Given that most renewable projects consist largely of upfront capital investments and very low ongoing expenses, and none that are correlated with future market prices, this makes lenders hesitant to provide loans to such projects. Absent such lending, the

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14 See for example Matthias Kalkuhla, Ottmar Edenhofera, Kai Lessmanna, *Learning or Lock-in: Optimal Technology Policies to Support Mitigation*, 2011

15 For example, based on the quality of the local resource, the UK and Scandinavian countries may find support of offshore wind more attractive than significant support for solar PV, whereas the Middle East and North Africa may find solar technologies more attractive for the same reason.

16 Other risks such as construction risks and performance risks might remain, but those may well be small enough so as to not prevent banks from lending.

number of renewable projects that can be financed (through pure equity or through balance-sheet financing[17]) will be smaller than if debt is available to leverage project finance, resulting in a higher total cost of achieving any given renewable energy target. It is furthermore unlikely that utility balance sheets and available equity will be sufficient to finance the investments in low-carbon technologies needed to meet policy goals.

It may therefore be justified to provide some form of revenue support to potential project lenders in order to lower the uncertainty of future revenue streams and the associated financial costs, thus inciting broader capital markets to participate in financing all the investments in low-carbon technologies needed to meet existing (and likely evolving) policy goals.

Many of the approaches already discussed and further explained in the case studies below fall into this category. In addition, mechanisms such as loan guarantees such as those made available under Sections 1703 and 1705 of Title XVII of the Energy Policy Act of 2005 in the United States[18] and similar mechanisms also potentially meet this objective. Still, the efficiency and cost effectiveness of loan guarantees has been hotly debated, questioning whether or not government is well qualified to choose likely winners by investing in particular projects or companies and hence opening the door for improvements to such policies[19].

C. Direct Support as "Second Best"?

In this final subsection we return to the question of whether, on balance, there is a substantial argument in favor of separate and perhaps technology-specific support for renewable energy in addition to using either a tax or cap-and-trade approach to internalizing various environmental externalities, or whether such support remains inferior under realistic assumptions about the real world to either of those two direct approaches to pricing existing externalities.

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17 "Balance-sheet" financing means that a larger company with a diversified set of activities borrows against all of its revenues and assets and uses the corporate level debt and equity to finance renewable projects. This is in contrast to project financing, where debt is used to finance a specific project and is secured only by the revenue stream from that project.

18 See for example Gregory H. Kats. President of Capital E, DOE 1705 Loan Guarantee Program: Success or Failure? Statement Before the House Committee on Oversight and Government Reform, May 16, 2012. See also Benjamin Boroughs et al., Assessing the Value of Loan Guarantees as an Instrument for Supporting the Deployment of New Clean Energy Technology, Center for International Science and Technology Policy, 2012, which concludes that the loan guarantee program has been successful in increasing the pace of renewable energy development by enabling financing of projects which otherwise would have been unlikely to obtain such financing (pages 27 ff.)

19 This argument has gained momentum following the Solyndra bankruptcy. For a discussion of the issues surrounding the federal loan guarantee program, see for example Phillip Brown, Loan Guarantees for Clean Energy Technologies: Goals, Concerns, and Policy Options; Congressional Research Service, January 17, 2012. For a more critical view, see also the testimony by Veronique de Rugy, Assessing the Department of Energy Loan Guarantee Program, Mercatus Center, George Mason University, 2012.

Based on our review of the literature, we conclude that while there are arguments in favor of direct renewable support such as the existence of knowledge spill-overs and capital market failures, there remain important questions as to the efficiency of implementing such policies in ways that achieve results in a cost-efficient manner. The main theoretical concern is that by providing technology specific support, the resulting mix in technologies used to address environmental externalities is inefficient because the technology-specific support schemes are not optimal. Even if governments were attempting to provide efficient support, the setting of either technology-specific FITs or setting technology-specific quantity targets requires knowledge of costs and cost trajectories the government is unlikely to possess. In addition, there are risks that government policy will not be based on a rational analysis of the optimal support system, but rather will be captured by various industry groups, resulting in high support for those industries with strong lobbying efforts.

In more practical terms however, there are at least two reasons why direct and technology-specific support for renewables may either be efficient or at least second best and the only realistically feasible option. We have outlined the reason why direct and technology-specific support may be optimal above. It consists of the presence of additional externalities (knowledge, capital markets) which lead to statically optimal responses to environmental externalities being dynamically inefficient. Put more simply, it is at least possible that with a pure carbon pricing approach some low-carbon technologies, in particular those that are relatively mature, will get locked in and newer, as of yet substantially more expensive technologies with significant cost-reduction potential get locked out. Over a longer time horizon, this could result in higher costs to society. Also, and more pragmatically, carbon price levels needed to achieve the penetrations of low-carbon technologies in order to achieve overall policy goals may by themselves not be politically attainable and more direct support for certain technology may be the only feasible solution to encourage the development of currently less mature low-carbon technologies.

Finally, empirically, countries deploying renewable energy in substantial quantities all use direct support systems for renewable energy, with or without an accompanying system of direct carbon pricing. And in countries subject to a common carbon price signal, those countries with strong complementary renewable energy support tend to see stronger and more cost-effective advances of renewable energy.

This report will not settle the remaining uncertainty over the effectiveness of direct renewable support when compared to direct pricing of environmental externalities. However, this section does establish the broad rationale underlying some form of support for renewable energy. With the rationale established, the next section develops several case studies of different approaches to such support in the United States and in Europe. The purpose of this section will be to identify key ingredients of renewable support that seem to be associated with successful development of renewable technologies.

IV. SELECTED DOMESTIC AND INTERNATIONAL CASE STUDIES

In this section we examine a number of case studies in detail. The case studies, of two US states and two European countries, were chosen in part because renewable energy in those states and countries is perceived as making substantial progress or because each example provides useful insights into the process of developing and perhaps more importantly adapting a renewable support system in response to perceived inadequacies. We look at California, which is in the process of ramping up to meet a very substantial goal of 33% electricity supply from renewable energy by 2020. We also look at Massachusetts, which has experimented with a number of approaches to renewable energy support. Internationally we examine the case of Germany, which is seen as a poster child of renewable energy success, at least in terms of having achieved impressive growth in renewable energy development. We conclude by closely examining the experience of the United Kingdom, which has also gone through a series of evolutionary changes of its renewable energy support programs.

A. Domestic Case Study: California

California is often seen as a leader in the development of renewable energy in the United States. Given the size of the state economy, California's renewable electricity target of 33% by 2020[20] is likely the most ambitious in the United States. It seems therefore appropriate to look at the mix of renewable support systems deployed by California to reach its ambitious targets.

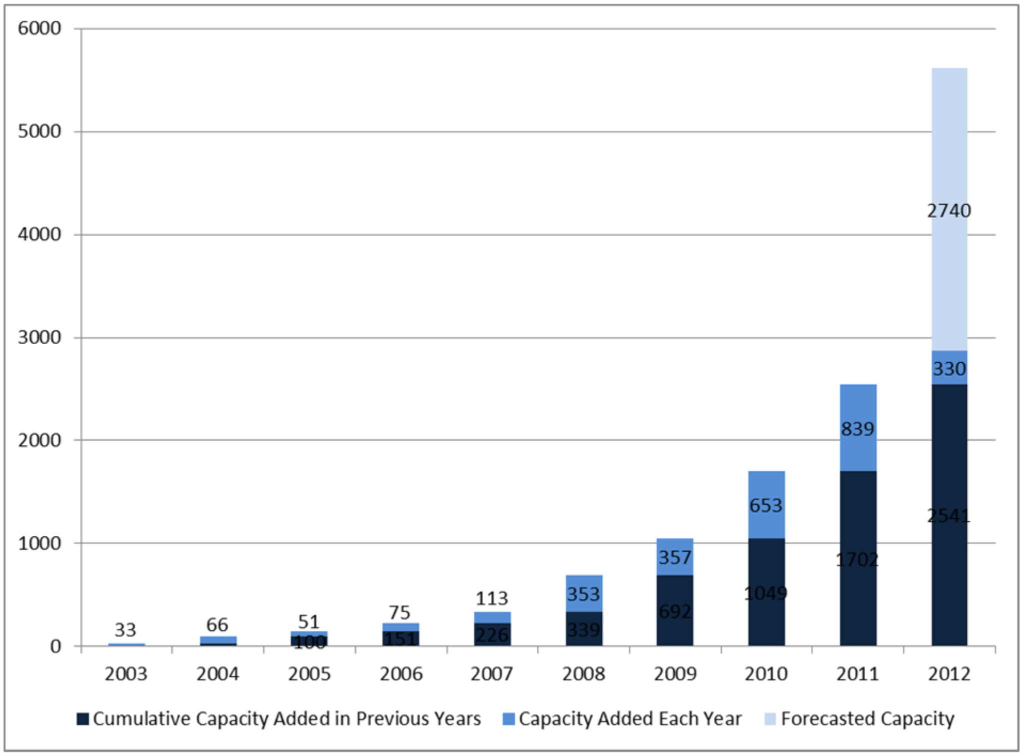
Figure 1 below shows how renewable electricity has been growing in the state since 2003[21]. As Figure 2 below shows, there is some indication that California has ramped up renewable electricity development so fast that it is now clearly on a path to reaching its ambitious goal.

While it thus appears that California's policies have been successful, it is important to also understand what if any concerns have been raised in this context. In the rest of this section, we will describe the various aspects of California's renewable electricity support system in more detail.

[20] California's 20% RPS by 2020 was established in 2002. Senate Bill 2 of the First Extraordinary Session (SB 2 (1x)) (Simitian) expanded the mandate to a 33% RPS by 2020. It was signed into law by Governor Jerry Brown on April 13, 2011.

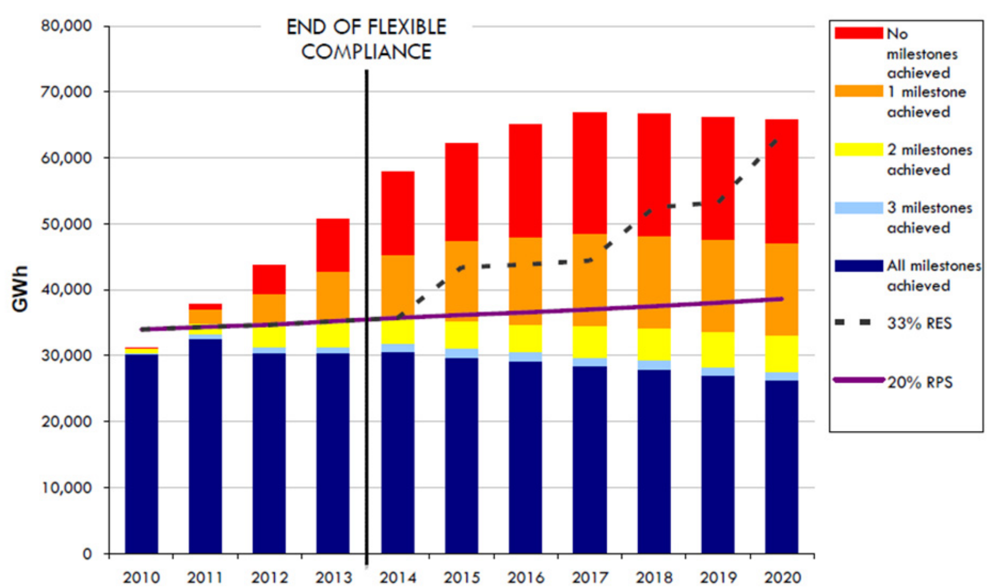
[21] CPUC, Renewable Portfolio Standard Quarterly Report, 1st and 2nd Quarter 2012.

Figure 1: RPS Capacity installed per year since 2003



Source: Reproduced from Figure 1, California Public Utilities Commission, Renewable Portfolio Standard Quarterly Report, 1st and 2nd Quarter 2012

Figure 2: California's Renewable Development Path relative to RPS Targets



Source: Reproduced from Figure 1, California Public Utilities Commission, Division of Ratepayer Advocates, *Green Rush: Investor-owned Utilities Compliance with the Renewables Portfolio Standard*, February 2011

Brief History of Renewable Policy in California

California's renewable support started in 1998 in the wake of electric power restructuring with the California Energy Commission's ("CEC") Emerging Renewables Program ("ERP"), which funded grid-connected solar projects under 30 kW, small wind systems, fuel cells (using a renewable fuel), and solar thermal projects. Between 1998 to 2006, the California Public Utilities Commission ("CPUC") funded larger self-generation projects for businesses[22].

Effective 2007, the solar portion of the ERP was replaced with two programs for on-site solar projects: the CEC's New Solar Homes Partnership and the CPUC's California Solar Initiative ("CSI"). In addition, today a variety of solar programs are offered through the publicly owned utilities. This statewide effort is known collectively as Go Solar California and has a statewide campaign goal of 3,000 MW of solar generating capacity with a budget of $3.35 billion.

The CSI provides cash rebates for solar projects smaller than 1MW to existing and new non-residential properties. It has a budget of $2 billion over 10 years and a goal of 1,940 MW of installed solar capacity by 2016. There is some indication that the CSI is helping to reduce solar PV costs due to the creation of economies of scale. In particular, solar PV retail prices seem to have fallen more quickly than component costs[23].

The New Solar Homes Partnership has a goal of 400 MW of solar capacity installed in new residential construction by 2016 through various incentive programs, with a budget of $400 million, offers incentives to encourage solar installations.

In 2002, California established a Renewables Portfolio Standard ("RPS") with the goal of reaching a share of 20% renewable energy in the state's electricity mix by 2017.

The California Energy Commission recommended to accelerate that goal to 2010 and to increase the target to 33 percent by 2020, a goal that was ultimately passed into law with enactment of the California Global Warming Solutions Act in 2006 ("AB 32"). Apart from a 33% RPS by 2020, AB 32 includes a number of additional programs designed to lower California's greenhouse gas emissions to 1990 levels by 2020. They include a cap-and-trade program, a low carbon fuel standard and many other programs.

FITs in California

In 2008, California created a Feed-in-Tariff (FIT) program under Assembly Bill 1969, authorizing the purchase of up to 480 MW of renewable generating capacity from facilities smaller than 1.5 MW. Unlike FITs in Europe, which tend to be technology specific, The AB

[22] For more details on California's renewable energy support programs, see the website of the California Energy Commission (http://www.energy.ca.gov/renewables). See also CPUC, *Order Instituting Rulemaking to Continue Implementation and Administration of California Renewables Portfolio Standard Program*, Rulemaking 11-05-005, May 31, 2012.

[23] CPUC, Division of Ratepayer Advocates, *California's Solar PV Paradox: Declining California Solar Initiative Prices and Rising Investor Owned Utility Bid Prices*; October 2010, page 12.

1969 FIT program set the price paid to small generators at the level of the Market Price Referent ("MPR"). In the spring of 2012, the CPUC implemented a new pricing mechanism and program rules, increasing the eligible project size from 1.5 MW to 3 MW, changing the methodology for calculating the FIT, created the renewable market adjusting tariff ("Re-MAT"), a mechanism that allows the FIT price to adjust based on market conditions and increased the overall statewide size of the FIT program to 750 MW.

The change to the FIT structure was in response to limits imposed by the Federal Energy Regulatory Commission ("FERC") with respect to individual states' ability to set tariffs for electric generators outside the realm of qualifying facilities ("QFs") under the Public Utility Regulatory Policy Act ("PURPA").

When determining an appropriate compensation mechanism under Re-MAT, the CPUC considered, but rejected the use of technology-specific rates, in part, but not exclusively because of legal issues related to justifying differentiated rates by technology that are linked to avoided costs[24].While not fully technology specific, the new Re-MAT mechanism does offer a different price for three different product types covering somewhat related technologies: base load (e.g. bioenergy and geothermal), peaking as-available (solar), and non-peaking as-available (wind, hydro).

For each of the three FIT product types, the Re-MAT starting price was originally based on the weighted average of the three major investor owned utilities' highest executed contract resulting from the Renewable Auction Mechanism ("RAM") auction – discussed below - held in November 2011. Since then, the price for each of the three product types can increase or decrease every two months under certain conditions. FIT prices are made publicly available.

To participate in the program, interested and eligible generators have to submit a participation request to the utility and are then added to a queue on a first-come-first-served basis for each product type. Every two months, the utility offers generators a FIT contract at the then current Re-MAT price in order of the Re-MAT queue and, if a generator accepts the price, it enters into a FIT contract. The price is fixed for the term of contract, which is either 10, 15 or 20 years. If the generator declines, it maintains its position in the queue until the next two-month period.[25] The Re-MAT price gets adjusted upwards if less than 50% of the target capacity for a given project type accepts FIT contracts. The amount of increase over the previous 2-month Re-MAT price increases by $4/MWh each time the previous round remained below 50% of target capacity. For example, if the first Re-MAT were 100, then the subsequent Re-MATs would be $104/MWh (100+4), $112/MWh (104+8), $124/MWh (112+12), $140/MWh (124+16), etc. A corresponding decrease in the Re-MAT price results if more than 100% of the target capacity is being met by projects in the queue.

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24 CPUC, *Order Instituting Rulemaking to Continue Implementation and Administration of California Renewables Portfolio Standard Program*, Rulemaking 11-05-005, May 31, 2012, pages 33-35.

25 Ibid, page 45.

As such, California's FIT is originally based on the prices for renewable projects that result from the competitive procurement process for somewhat larger projects, and then adjusted upwards or downwards depending on whether there is enough demand from the smaller scale projects eligible for the FIT at those price levels. The California FIT can therefore be characterized as an attempt to tie price levels to actual market information and thus avoid setting FIT levels too high (or too low) with the corresponding impact of rate payers paying too much for renewable energy support.

It is worth mentioning that in several parts of the US including California, smaller utilities are beginning to offer forms of FITs. For example, the City of Palo Alto is offering a CLEAN ("Clean Local Energy Accessible Now") program to purchase electricity generated by solar systems with differing rates for contracts of 10, 15 and 20 years duration. The goal is to add up to 4 MW of solar capacity by year-end 2012. The current incentive levels run out when this target is reached or at year-end 2012, whichever comes first[26].

Renewable Auction Mechanism for mid-sized projects

The RAM, is a simplified market-based procurement mechanism for renewable distributed generation (DG) projects between 3 MW and 20 MW on the system-side of the meter and is California's primary procurement tool for system-side renewable DG. It allows bidders to set their own price, provides a simple standard contract for each utility, and allows all projects to be submitted to the CPUC through an expedited regulatory review process. Eligible technologies include wind turbines, waste heat to power technologies, pressure reduction turbines, internal combustion engines, micro-turbines, gas turbines, fuel cells, and advanced energy storage systems.

Qualifying renewable generators cannot also participate in parallel in other renewables support programs providing incentives, such as the CSI, which provides rebates to qualifying distributed energy systems installed on the customer's side of the utility meter.

The CPUC also authorized the IOUs to own and operate solar PV facilities and to execute solar PV power purchase agreements with independent power producers (IPP) through a competitive solicitation process. If fully implemented, it will result in up to 1,100 megawatts (MW) of additional solar PV capacity in California over a five-year period. The PV capacity installed under the program will qualify to meet the IOUs RPS requirements.

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[26] For a detailed program description, see City of Palo Alto Utilities, *Palo Alto Clean: Clean Local Energy Accessible Now; 2012 Program Handbook*, March 2012

California's RPS, RECs and long-term contracting

To date, the fast majority of compliance with the California RPS has been through the signing of long-term contracts for bundled electricity and RECs. More specifically, the RPS allows the three large investor-owned utilities to contract with renewable generators using either bilateral contracting or through the annual issuing of Requests for Offers ("RFOs"). The issuing of RFOs is preceded by an annual RPS procurement plan filed with the CPUC. Until 2008, all procurement for renewable energy was through bundled contracts[27]. However, long-term contracts for bundled energy and RECs were believed to have some draw-backs. In particular, there were concerns about deliverability of renewable energy to the entities subject to the RPS, given the existence of transmission constraints. Also, the long-term contracting part was believed to be problematic with respect to the competitive segment of electricity supply – since there is no guarantee that customers will remain with the entity buying under the long-term contract. At the same time, it was also understood that long-term contracts were critical to allow financing of renewable projects[28].

Recent revisions to the RPS allow procurement of unbundled products for some portion of the overall RPS obligation. The portion of the total obligation required to be procured through bundled products is 50% between 2011 and 2013 and increases to 65% between 2014 and 2016 and to at least 75% between 2017 and 2020. At the same time, the portion of the RPS obligation that can be met through "REC-only" contracts declines from up to 25% between 2011 and 2013 to 15% and ultimately 10% after 2017[29].

In general, proposals received through the RFOs are evaluated against the MPR, but also against other proposals received. Because the MPR generally represents the future market price of conventional power, many renewable proposals PPAs so far have been signed at prices in excess of the MPR. As of 2011, 59% of the renewable contracts signed by the three IOUs were at prices above the MPR, with an average mark-up of 15%[30]. As a cost-containment measure, the California legislature therefore required that the CPUC maintain an account of "above-market funds" ("AMFs"), which are allocated to each utility for competitively-sourced renewables projects above the MPR. Each utility was allocated a set amount of AMFs, which was collected from ratepayers through the Public Goods Charge. Upon exhausting its share, each utility can continue to bear above-market renewable costs on a voluntary basis with CPUC approval[31]. It is questionable whether the attempt to control cost

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27 See for example Sara Kamins and Jack Stoddard, *California's Renewable Energy Portfolio Standard: Implementing one of the most ambitious renewable energy standards in the country*, CPUC, April 2008.

28 See Andy Schwartz, *Renewable Energy Certificates and the California RPS*, CPUC, 2006, page 9-11.

29 See CPUC, *Decision (D.) 11-12-052 on Portfolio Content Categories implements SBx1 2 restrictions on unbundled renewables*,

30 See CPUC, Division of Ratepayer Advocates, *Green Rush: Investor-owned Utilities Compliance with the Renewables Portfolio Standard*, February 2011, page 8.

31 For an example of a request of a California utility for approval of a contract with a renewable project and a discussion of the evaluation criteria and relationship to MRP, see Southern California Edison, *ADVICE 2582-E (U-338-E)*, May 11, 2011, Page 10ff.

as intended has so far been successful. The CPUC's Division of Ratepayer Advocates estimated that of the 184 renewable energy contracts submitted to the CPUC between 2002 and 2011, only 2 were rejected and that the total AMF amounts represented by the approved contracts were in excess of $6 billion, or more than seven times the AMF originally allocated[32].

Perhaps in response to this finding, in 2011, Senate Bill No. 2 (SB2) required the CPUC to establish a limitation for each utility subject to the RPS on the total expenditures to comply with the renewables portfolio standard[33]. As of the writing of this report, the CPUC is still in the process of developing such a cost containment mechanism.

Part of the high cost seems to be related to the signing of an increasing number of relatively costly utility scale PV contracts. Here, the CPUC's Division of Ratepayer Advocates observes that unlike under the CSI, contract prices do not reflect the decline in component costs, but rather that contract prices have tended to increase[34]. Among the potential reasons discussed, apart from the above mentioned tendency by the CPUC not to disallow contracts due to high prices, is the fact that the ambitious 33% RPS with relatively limited compliance flexibility has created a sellers' market[35] – essentially reducing the chances that a project will not receive a contract by bidding at a higher price, and the fact that renewable generation supported under CSI currently does not count towards California's RPS program.

The CPUC Division of Ratepayer Advocates analysis itself has been criticized for failing to explain why solar costs in California even under the CSI have fallen relatively little when compared to countries using a FIT[36].

AB 32 and Cap-and-Trade

It is worth pointing out that California is about to implement a carbon pricing scheme in the form of a cap-and-trade program, which is part of AB32. While not providing direct support for renewable electricity, it will create a price of greenhouse gas emissions and thus improve the relative cost of GHG-emissions free energy sources relative to fossil-based power supply. It is also worth noting that AB32 does not replace the RPS or other policies designed to support the development of renewable energy sources with the cap-and-trade program, but rather treats them as complementary policies.

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32 See CPUC, Division of Ratepayer Advocates, *Green Rush: Investor-owned Utilities Compliance with the Renewables Portfolio Standard*, February 2011, page .

33 See http://www.cpuc.ca.gov/PUC/energy/Renewables/procurement.htm

34 CPUC, Division of Ratepayer Advocates, *California's Solar PV Paradox: Declining California Solar Initiative Prices and Rising Investor Owned Utility Bid Prices*; October 2010, page 13ff.

35 It is useful to note that in California non-compliance with the RPS mandates may result in penalties for shareholders. Unlike in states like Massachusetts, utilities in California who do not manage to procure renewable power to meet their mandate cannot comply through an Alternative Compliance Payment (ACP), which in turn can be recovered from ratepayers.

36 See for example Paul Gipe, *The California Solar Paradox: Why Does DRA Overlook the Cost Control Feature of Feed-in Tariffs?*, November 2010 (downloaded from windworks.org)

Lessons Learned from California

The trajectory of renewable energy development in California contains several important lessons with respect to the design and implementation of renewable energy support systems.

First, it appears that procurement through the use of long-term contracting has been critical to the financing of large amounts of renewable projects, in particular utility-scale projects. California is on track to meet and perhaps exceed its ambitious RPS and while the "but for world" of a system in California that does not rely on long-term contracts to reduce revenue risks for project developers cannot be directly observed, the experience elsewhere, including in Massachusetts as discussed below, suggests that providing relative revenue stability through long-term contracts has been very important.

It is also interesting to observe the gradual shift towards the use of FITs as a means of providing revenue certainty for at least some applications, such as small scale PV deployments. This is perhaps an indication that FITs, at least in theory and if properly implemented, might provide the same revenue certainty with substantially reduced transaction costs. At present, California seems to be weighing the pros and cons of FITs versus long-term contracts, the former reducing transaction costs, the latter allowing more rapid responses to changing market conditions and perhaps less risk of ex-post regrets about support levels. As the complex process for setting FIT prices under the RE-MAT procedure shows, the advantage of simplicity may become smaller with attempts to have the FIT reflect more market information. We discuss the use of FITs more below in the context of international experience with renewable energy support.

A second theme is the emergence of more technology-specific support, either directly, through incentives solely targeting specific technologies, in particular solar PV, or indirectly, through the signing of long-term contracts for solar projects even if the associated PPA prices might exceed those for alternative technologies such as wind.

B. Domestic Case Study: Massachusetts

We have chosen Massachusetts as our second domestic case study for two reasons: First, like California, Massachusetts is generally seen as a state aggressively pursuing renewable energy. However, as Figure 3 below shows, early ambitions created through its RPS did not necessarily result in large and fast development of renewable energy sources. As a consequence, Massachusetts policies towards renewable electricity have been evolving. Below we describe in detail both the original set of support structures and their evolution over time. Figure 4 shows RPS compliance by technology.

Figure 3: Massachusetts RPS Compliance since 2003

	2003	2004	2005	2006	2007	2008	2009	2010
Surplus Banked	61	20	1	9	81	211	386	241
ACP Compliance	0	265	368	323	11	1	0	4
Compliance from Banked	255	61	20	2	7	81	190	381
Compliance Year Generation	304	445	645	939	1600	1896	2130	2324

Source: Figure One, RPS Class I Compliance, 2003-2010, Massachusetts Renewable and Alternative Energy Portfolio Standards (RPS & APS) ANNUAL COMPLIANCE REPORT FOR 2010, January 11, 2012, page 11.

Brief History of Renewable Policy in Massachusetts

Massachusetts established a Renewable Portfolio Standard ("RPS") as part of its electric industry restructuring legislation in 1997. In 2002, the Department of Energy Resources ("DOER") adopted RPS regulations requiring a share of 4% renewable electricity by 2009. At the time it was assumed that the RPS by itself would lead to the least-cost renewable energy generation sources to be built. However, early experience with the RPS showed that project developers found it difficult to obtain financing for their projects based on uncertain revenues from the sale of renewable energy certificates ("RECs"), which represented an important part of the total revenues from renewable projects. Part of the problem was perceived regulatory risk, given that the Legislature and Executive Branch could revise or repeal the RPS at any time. Also, even if the RPS remained unchanged, predicting future REC prices was difficult[37].

To address these concerns, the Massachusetts Technology Collaborative ("MTC") established the Massachusetts Green Power Partnership ("MGPP") in 2003. Through the MGPP, MTC offered to purchase RECs under 10-year contracts as well as to sell various financial instruments designed to lower the revenue risk associated with selling future RECs, in particular various types of option contracts[38]. Under the MGPP program, MTC initially made 13 awards with a total obligation of $73.4 million. Some of these projects were later cancelled

[37] MTC, *Renewable Energy Results for Massachusetts, A Report on the Renewable Energy Trust Fund 1998–2008*, page 9.

[38] Nils Bolgen, *Using Long-Term REC Contracts to Help Developers Secure Project Financing*, Massachusetts Technology Collaborative, 2004

or received other funding, but MTC claims that MGPP funding helped secure 99 MW of new renewable capacity[39]. Nonetheless, development of renewable energy in the early years of the RPS was sluggish, with a significant portion of the RPS compliance obligation being covered through payments of the Alternative Compliance Payment ("ACP"), essentially designed as a safety valve against the possibility that meeting the RPS would be too costly for ratepayers, rather than through retirement of RECs generated from actual renewable projects[40].

In 2008 the Green Communities Act ("GCA") was passed and responsibility for renewable energy was moved from the MTC to a new entity Massachusetts Clean Energy Center ("MA CEC"). At the same time, the RPS goal was increased to 15% by 2020, to increase by 1% per year thereafter indefinitely (in theory until reaching 100%).

The GCA not only increased the RPS targets, it also included, for the first time, a formal requirement for the regulated distribution utilities to purchase some renewable power under long-term contract, likely at least in part due to evidence suggesting the importance of long-term contracts for renewable energy project development[41]. In particular, Section 83 of the GCA requires at least two solicitations for renewable energy through long-term contracts between 2009 and 2014 for a total of approximately 3% of total retail load. By 2012, all distribution companies had solicited and subsequently signed contracts, including the contract signed between National Grid and Cape Wind LLC.

In April 2012, the Massachusetts Senate passed Senate Bill (SB) 2214, which adds a Section 83a to the existing legislation and would increase the percentage of total retail load to be covered with long-term contracts from renewables with durations between 10 and 20 years from 3% to 7% by December 31, 2016. In 2016, the Massachusetts RPS will require that 11% of total demand be supplied from Class I renewable resources. This implies that with SB 2214 almost 2/3 of total RPS requirements will be met through long-term contracts signed under Section 83 or Section 83a of the GCA[42]. It seems clear that the important role long-term contracting plays in making renewable projects feasible is at the core of the desire to increase the portion of total demand met by long-term contracts for renewable power. Hence, the law explicitly states that the long-term contracting requirement is "to facilitate the financing of

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39 MTC, *Renewable Energy Results for Massachusetts, A Report on the Renewable Energy Trust Fund 1998–2008*, page 9.

40 Rick Hornby, Ben Warfield, Robin Maslowski, *Role of Long-Term Power Purchase Agreements in Fostering Development of Wind Energy Projects in New England*, Synapse Energy Economics, Inc., December 2007, pages 1-2.

41 Ibid.; The study provides both theoretical arguments in favor of long-term contracting and empirical evidence showing that the vast majority of renewable energy projects analyzed relied on some form of long-term contracting.

42 For a detailed description of the current RPS, see Massachusetts Department of Energy Resources , Executive Office of Energy and Environmental Affairs , Commonwealth of Massachusetts , *Massachusetts Renewable and Alternative Energy Portfolio Standards (RPS & APS), ANNUAL COMPLIANCE REPORT FOR 2011*, January 11, 2012

renewable energy generation[43]". For example, Massachusetts Governor Deval Patrick noted in a speech given on May 30, 2012:

"We are working closely with the Legislature for an increase in the long-term contracts requirements so that more projects get built in the next few years.[44]"

Solar Carve-Out and other solar incentives

In 2007, Massachusetts established a solar rebate program, which led to the development of 27MW of PV by the end of 2009[45]. A follow-on project, Commonwealth Solar II, continues to provide rebates for small solar PV installations (smaller than 15 kW). Under the Commonwealth Solar program, installation costs have been falling steadily, although it is not clear to what extent the cost declines are due to the program itself or the general decline particularly of module prices since 2007.

In 2010, Massachusetts added a solar carve-out to its RPS. The program provides specific incentives for solar PV installations smaller than 6 MW in size with the goal of reaching 400 MW of installed solar PV capacity. Unlike the regular RPS, which has an ACP of currently approximately $65, the solar carve-out started with an ACP of $600 in 2010, which is reduced annually by the Massachusetts Department of Energy Resources ("DOER"). The program includes some innovative features. For example, the minimum standard in each year is adjusted based on a relatively complex formula, which in essence tries to accelerate the minimum standard if past installations have grown faster than anticipated, and to reduce the growth of the standard in the opposite case. The 2012 minimum requirement is 0.1630% of retail load, or 81.56 GWh[46]. The ACP declines at an annual rate of approximately 5% with the future schedule of ACP known in advance (it drops to $448 by 2017 and to $365 by 2021). Also, there is an auction mechanism for solar-RECs (SRECs) with a price floor of $300 (minus a $15 auction fee). Depending on whether the development of PV is faster or slower than anticipated, the number of quarters a project can participate in the auction – equivalent to the number of quarters the project is assured to receive at least the price floor for its SRECs – is adjusted down or up respectively, according to a formula[47].

In March 2011, Massachusetts also launched the Solarize Massachusetts pilot program, which attempts to bundle residential customers' PV installations to obtain more attractive pricing from installers. The pilot, carried out in four communities over a six-month period in 2011, resulted in attractive pricing relative to the typical cost of installations. In each city, installers

43 220 CMR 17.01 (1): Purpose

44 Governor Deval L. Patrick, *Shaping Our Energy Future* - As Delivered FastCap, Boston, Wednesday, May 30, 2012, downloaded from http://www.mass.gov/governor/pressoffice/speeches/20120530-shaping-our-energy-future.html

45 DOER, Massachusetts RPS Solar Carve-Out: Overview & Program Basics, November 2, 2011

46 See http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/current-status-of-the-rps-solar-carve-out-program.html

47 DOER, Massachusetts RPS Solar Carve-Out: Overview & Program Basics, November 2, 2011, page 17.

were asked to bid for installing several tiers of total capacity (<100kW, 100-200kW, 200-300kW and >300kW). For the top tier (>300kW), installers offered installed prices between $4 and $4.93/Wp, substantially below the $5.72/Wp average installation price in the same time period observed in the Commonwealth Solar II program. All residents, who signed up for the program received the installation price for the tier ultimately installed, which removes any disincentive for committing early – and in essence creates an incentive in the community to convince others to participate[48]. Based on the results of the Pilot, Solarize Mass is being rolled out to 17 additional communities in 2012. Results of the 2012 program were not available at the time of writing of this report.

Lessons learned from Massachusetts

The key lesson from Massachusetts' experience with renewable energy support is the recognition of the importance of revenue certainty for project development and that RPS, by itself, likely does not provide enough revenue certainty. Even though, in theory, private financial markets should provide tools (such as derivatives) that could turn an uncertain revenue stream from the sale of RECs into a certain revenue stream through the use of appropriate hedging products, such measures did not develop enough to overcome the risks associated with RECs volatility. Attempts to substitute publicly provided hedging products for the missing private ones ultimately did not prove effective, perhaps in part because they only addressed uncertain revenue streams from RECs, and not from the sale of power. In recognition of this, Massachusetts has been moving towards complementing its RPS with increasing requirements for procurement of renewable power through long-term contracts.

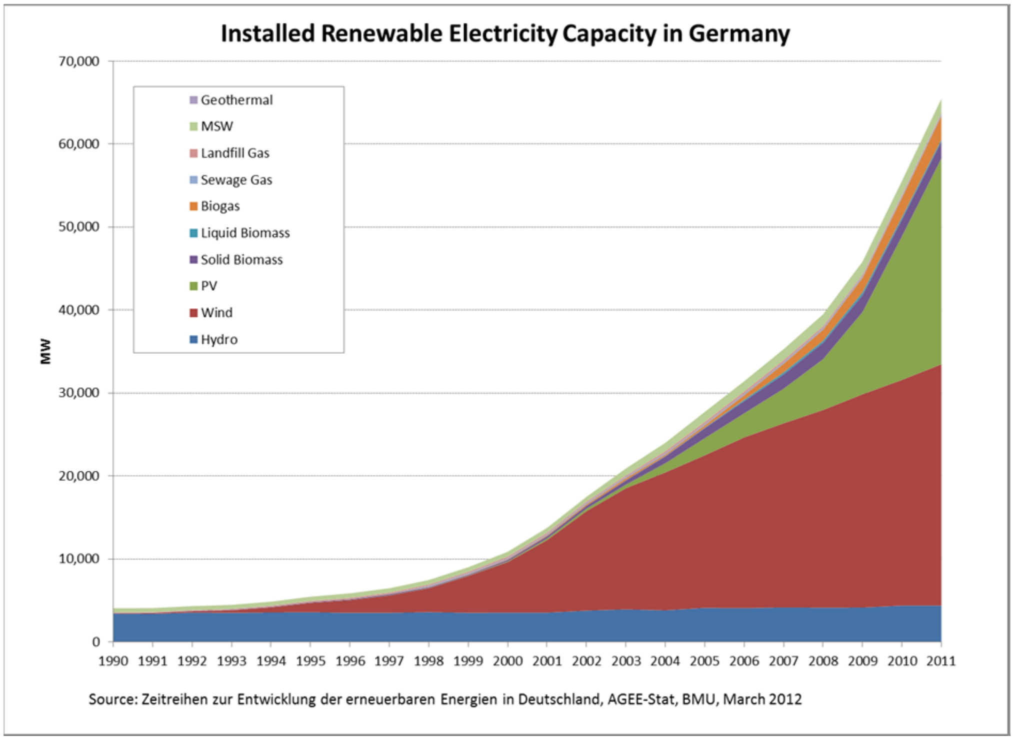
A second lesson was that absent technology specific support, in the case of Massachusetts in the form of a solar REC program, RPS compliance would likely be dominated by the currently cheapest technologies, leading over time to a lack of diversity and hence, at least ex-ante, in a risk that in the long run the technologies with the highest potential for cost reductions may not be able to mature.

C. International Case Study: Germany

Germany is often considered the poster child of renewable energy support and development, even though there is increasing criticism, both inside and outside of Germany, of the total cost incurred by Germany for supporting the development of renewable energy. Nonetheless, in terms of deployed renewable energy capacity, Germany is one if not the leading nation in the world. As shown in Figure 4 below, the growth of wind and solar PV generation capacity over the last decade has been impressive.

48 For more details on the program, see Massachusetts Clean Energy Center, *Solarize Mass Pilot Overview*, February 2012

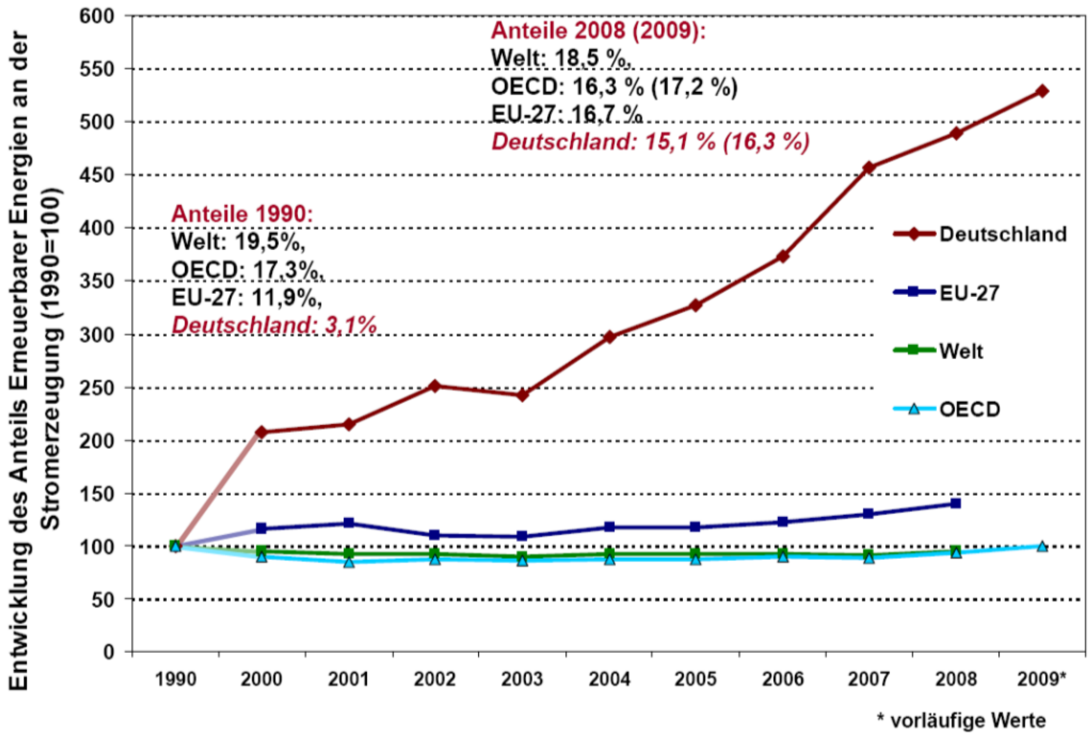
Figure 4: Evolution of Installed Renewable Capacity in Germany



By the end of 2011, Germany ranked 3rd globally in wind capacity (behind China and the United States) and 1st in PV capacity[49] and is far outpacing the rest of the EU and the world in renewable energy development, as can be seen in Figure 5 below. Given this rapid growth relative to other countries in Europe and beyond, Germany renewable energy policy is an obvious candidate for an in-depth look in the context of this paper.

49 REN21, Renewables 2011 Global Status Report, pages 16-23.

Figure 5: Renewable Energy Growth in Germany and elsewhere



Source: Erfahrungsbericht 2011 zum Erneuerbare-Energien-Gesetz (EEG-Erfahrungsbericht)

A Brief History of Renewable Energy Support in Germany

Renewable energy support began in Germany in the mid-1970s in the wake of the first Middle East oil crisis and initially consisted primarily of R&D support. As of 1979, utilities were required to purchase renewable energy at "avoided cost" (a similar concept to the one embedded in PURPA, but less favorably interpreted). The Chernobyl accident and initial reports on the potential dangers from climate change led to a fundamental shift in German politics and popular opinion away from nuclear power and towards renewable energy. This movement resulted in the introduction of the Stromeinspeisungsgesetz ("StrEG") - the electricity feed-in law - taking effect on January 1, 1991. The law in essence provided for a fixed feed-in tariff of 13.84 Pfennig/kWh for "eco"-power and a higher 16.61 Pfennig/kWh for solar and wind power. The requirement of utilities to buy power from renewable energy sources was not for a limited number of years. The utilities were permitted to recover the additional payments through transmission and/or distribution charges[50]. Even though the payments under the law were relatively small, the decade following the introduction of the support system saw the number of windmills in Germany increase from roughly 1,000 in 1990 to over 10,000 by 1999[51].

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[50] Stromeinspeisungsgesetz vom 07. Dezember 1990 (BGBl I S. 2633)

[51] Die Zeit, *Das unterschätzte Gesetz*, September 22, 2006

The StrEG was replaced by the Renewable Energy Law (Erneuerbare Energien Gesetz or "EEG") in 2000 following the election of the left-green coalition government. The purpose of the EEG was to double the share of renewable energy in the power generation fuel mix by 2010 relative to 1997 to 12.5%. The EEG formally introduced a system of annual, regressive feed-in tariffs for renewable sources, differentiated by technology.

At the same time (1999), the government also introduced the 100,000 Solar Roofs Program with the goal of increasing solar PV electricity generation by subsidizing the installation of PV with capacity of 3kW or more. Under the program, grants of approximately €500 million led to a growth of installed PV capacity from 50 MW in 1998 to 350 MW in 2003.

Finally, 1999 also marked the introduction of the Market Incentive Program (MAP), which offered significant grants for the commercialization and deployment of renewable energy systems, which we discuss in more detail below in the context of German credit support beyond the use of FITs.

After the reelection of the left-green government in 2002, the EEG was reformed in 2004, most notably by significantly increasing the FIT levels for PV and biomass[52].

The most recent revisions to the EEG have resulted in a new set of FITs for each technology. For any given project the FIT applies for a period of 20 years, with renewable energy having priority dispatch and priority access to the transmission and distribution grid. Grid operators are required to purchase the output from renewable energy suppliers at the FIT. The total cost of the payments is recovered through a surcharge on electric bills. FITs are differentiated by project size and technology, are adjusted for new projects on an annual basis (with a decline rate of 0% to 9% per year) and some technologies receive additional support for some period of time (such as offshore wind).

The current version of the EEG operates with a target range for new PV installations between 2.5 and 3.5 GW per year, with further reductions of FITs if PV installations exceed this target range[53]. In the Spring of 2012, the Government sought further reforms to the EEG. On June 27, 2012, a compromise between the two chambers of Parliament resulted in modifications to the original reform proposals. Among other things, the compromise sets the overall cap on the capacity of PV to be supported under the EEG at 52 GW[54]. The new law lowers the FIT for PV and limits the compensation through the FIT for output from installations between 10kW and 1MW to 90% of the total output of such installations, beginning in 2014. As of April 1, 2012, the FITs for rooftop PV are 19.5 eurocents/kWh for PV installation smaller than 10kW,

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52 For an in-depth discussion, see Volkmar Lauber and Lutz Mez, Three Decades of Renewable Electricity Policies in Germany, ENERGY & ENVIRONMENT, vol. 15 no. 4 (2004), 599-623

53 Nicolas Oetzel, *Renewable Energy Sources Act (EEG): Key features and recent developments*, Athens, January 26, 2012

54 *Photovoltaik: Einigung im Vermittlungsausschuss*, article on www.energieverbraucherportal.de, downloaded on July 4, 2012.

18.5 eurocents/kWh for PV installations smaller than 40kW, 16.5 cents for PV installations smaller than 1MW and 13.5 eurocents/kWh for PV installation smaller than 10MW[55]

The role of debt support through the EIB and the Kreditanstalt für Wiederaufbau (KfW)

The KfW has put in place various additional support programs, currently for renewable heat applications, such as solar hot water, certain types of heat pumps, biogas combustion for heating purposes, etc. The support is similar to the US investment tax credit or Section 1605 Grants, i.e. a subsidy of principal payments for up to 30% of the investment amount, and also various additional rebates and low-interest loans combined with rebates[56]. KfW also offers low-interest loans for up to 100% of total project cost to residential households for PV installations and project debt for offshore wind projects, with a cap of 70% of the total debt and a maximum loan of €700 million per project[57]. Loans for PV installations totaled €9.5 billion in 2010 and €7 billion in 2011. While detailed data on the total capital investments in PV projects or the exact portion of KfW loans to support PV installations are not available, simple back of the envelope calculations suggest that a significant portion of total investment in PV is financed with the help of KfW loans[58]. The offshore loans from the KfW can be combined with financing through the EIB. The loans can be for up to 20 year-terms, with up to 3 years without repayment obligation at the beginning[59]. In its 2011 annual report, KfW states that it participated in financing 80% of German wind installations (and 40% of all renewable projects) with total loans of €10 billion[60]. It has set aside €5 billion in its off-shore wind financing program to co-finance up to ten offshore wind parks. By year-end 2011, KfW had committed to support two Germany offshore wind projects with a total of €544 million[61].

It seems clear that public financing through KfW plays a critical role in enabling the financing of large renewable projects, in particular the current first wave of large offshore wind projects. According to news articles, private investors (including private lenders and large institutional investors such as the largest reinsurance companies) find the risks of investing in offshore wind projects too high – and correspondingly the expected returns too low[62].

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55 *Die wichtigsten Änderungen der EEG-Novelle zur Photovoltaik 2012*(downloaded from www.bmu.de)

56 The "Marktanreizprogramm" (market incentive program or MAP) involves funds from KfW (low interest loans and rebates) and Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA). The detailed rules for MAP are available at http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/map_waerme_2011_en_bf.pdf

57 See http://www.kfw.de/kfw/en/Domestic_Promotion/Our_offers/Renewable_energy.jsp

58 In 2011, PV capacity in Germany increased by approximately 7.5 GW. Assuming an approximate cost of €2.5/Wp on average in 2011, the total capital cost of PV installations in Germany would have been €18.75 billion. Assuming the entirety of the KfW loan programs for renewables went to PV installations, KfW loans would have covered a bit under 40% of the total cost of PV installations in Germany in 2011 (for data, see http://en.wikipedia.org/wiki/Solar_power_in_Germany).

59 See kfW Bankengruppe, *Information Sheet on KfW Offshore Wind Energy Programme*, Programme number 273, October 2011.

60 kfW Geschäftsbericht 2011, page 12.

61 Ibid, page 34 and page 38

62 See for example Handelsblatt *, Finanzinvestoren sind Risiken auf hoher See zu gross*, April 17, 2012

Further debt financing support is provided from EU sources. For example, over the 2007-2009 time frame, €8.4 billion of loans were provided to various EU renewable energy projects by the European Investment Bank ("EIB") including Germany.

Key Lessons from German Renewable Energy Support

Both in absolute terms and relative to the total size of the electric power sector, Germany has been extremely successful in fostering the development of renewable energy. It remains the global leader in PV and still one of the leaders in wind (onshore), having developed a dynamic ecosystem of companies involved along the renewable energy supply chain. This is so despite the fact that Germany has recently seen its own share in bankruptcies particularly in the solar cell manufacturing space.

Since renewable energy still carries a cost above the cost of conventional power generation technologies (and the corresponding FITs remain above the average cost of wholesale power in Germany), the rapid rise in power generation from renewable sources is creating some upwards pressure on electricity rates, which has led to an intense debate about cost control going forward. In spite of these questions, there is relative agreement that these issues arise not so much because of a poorly designed renewable incentive system, but rather because of its success in terms of increasing renewable generation capacity.

The basis of the success seems to have been a relatively stable and transparent support environment based on FITs with regular price degressions, complemented by a significant amount of financing support by public lending institutions such as KfW and EIB. This stable environment was likely at least in part possible because of a relatively wide-spread agreement among the German population that climate change is a substantial risk and requires action, even if those actions require a financial sacrifice. There has also been relatively broad agreement that the development of renewable energy technology provides important opportunities for Germany to create a next generation of successful companies.

In light of this broad agreement, it is somewhat surprising, but perhaps understandable in the larger economic context that the government has recently taken steps that may make the regulatory environment less stable. In particular, it has recently changed the FITs for solar PV through several extraordinary degressions, which probably imposes significant risks for projects already in the queue (in the middle of development). Also, the latest amendments to the EEG in August 2012 resulted in a decision to limit the total amount of solar PV that can receive support through FIT to a total capacity of 52GW. There will be no more FIT support for solar power thereafter, even though the priority dispatch for solar (even beyond 52GW) will remain[63]. While it seems reasonable to assume that FIT support for emerging technologies should not be expected to continue forever, particularly assuming that all relevant environmental externalities are reflected in market prices, setting a MW ceiling for total installed capacity under FITs seems more motivated by the desire to limit total support payments to some total amount (in essence limiting rate increases) rather than on an objective

[63] See *Die wichtigsten Änderungen der EEG-Novelle zur Photovoltaik*, 2012, BMU, June 28, 2012

assessment on when the industry is mature enough to compete with other technologies absent FITs.

It is unclear what impact this will have on the certainty of receiving revenues especially as total installed capacity approaches the 52GW ceiling, but the policy may have some undesired effects. Incidentally, as we will discuss below, the UK government, in its proposed reforms to the electric power sector, is suggesting a similar approach, explicitly limiting the total financial support for renewables rather than setting a quantity ceiling.

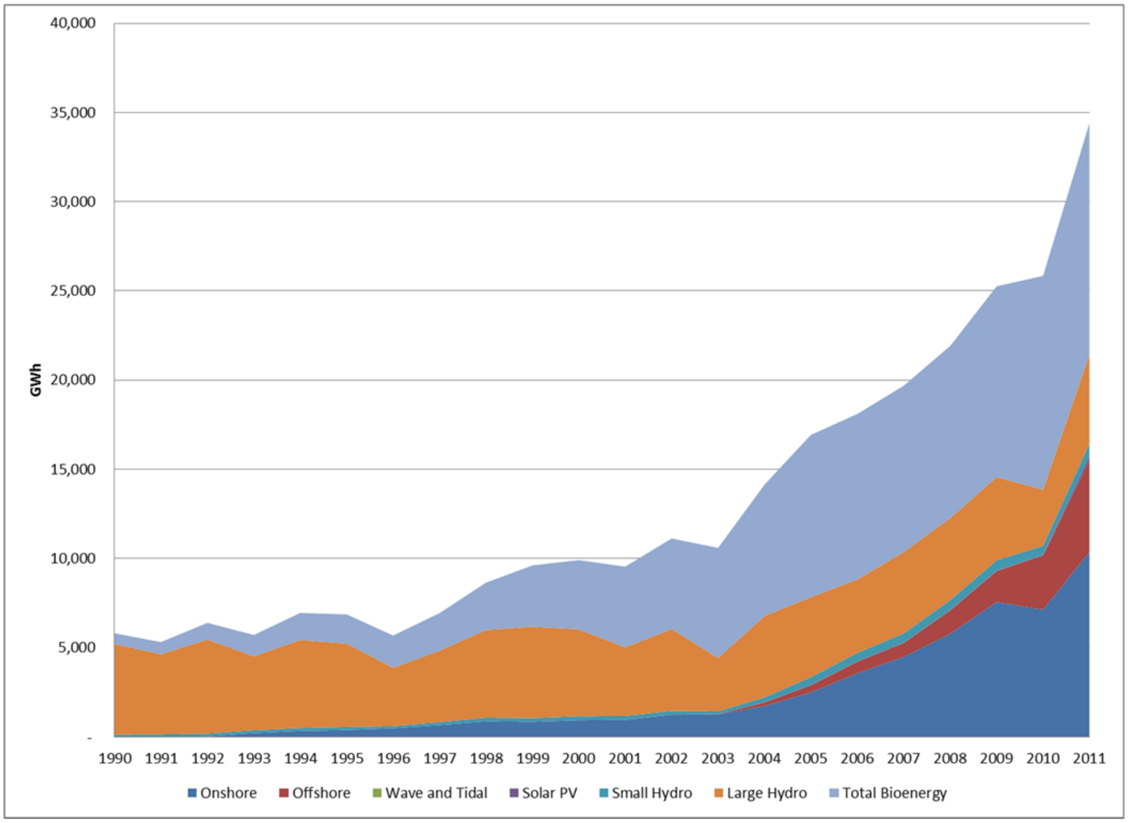
D. International Case Study: The United Kingdom

We chose the United Kingdom as our second international case study on renewable energy policy for a number of reasons. First, the development of public policy in the UK leaves a relatively transparent paper trail, making it possible to gain insights into the deliberative process leading up to the implementation of policy. Second, UK renewable support has gone through a serious transformation over the past two decades and we believe the reasoning behind the transformation may shed light on what works, what doesn't work and why. Finally, as illustrated in Figure 6 below, the UK's early efforts to develop renewables fell short of its own goals and of the progress made in other EU countries, creating the need to rethink policy in order to reach legally binding targets within the EU, which have been enshrined in UK law, most recently through the Climate Change Act 2008[64], which requires the UK to reduce its carbon emissions by at least 34% by 2020 and by at least 80% by 2050, relative to 1990. Also, the EU Renewable Energy Directive requires that the UK meet a target of generating 15% of energy from renewable sources by 2020.

As of 2012, the United Kingdom uses (or is about to use) a relatively broad set of measures to support the development of renewable energy. The main pillars include the renewable energy obligation ("RO"), the EU Emissions Trading Scheme ("EU ETS"), the UK Green Investment Bank and the climate change levy. In this section, we briefly describe each of these approaches, including a brief historic overview of their evolution.

64 See www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx for more details.

Figure 6: Evolution of Renewable Generation in the UK



Source:TBG Analysis, Digest of UK Energy Statistics 2011, Chapter 6, last updated July 26, 2012, Table 6.1

A Brief History of Renewable Energy Support in the United Kingdom

The Renewables Obligation and its successors

The United Kingdom first introduced support for renewable energy in 1990, in the context of the privatization of the UK power sector, in the form of the Non Fossil Fuel Obligation ("NFFO"). NFFO was funded through the Fossil Fuel Levy ("FFL"), which was placed on all consumers. The Regional Electricity Companies were obliged to purchase power from nuclear and renewable generators at a premium price. Projects to be supported through NFFO were selected through a set of capacity auctions, an approach quite similar to competitive procurement processes in the United States, but different at the outset from the FIT approach used in other European countries. The NFFO auctions were technology neutral[65].

In 2002 and in part as a result of the Utilities Act of 2000, which led to vertical unbundling of the industry, the UK abolished the NFFO and created the equivalent of a renewable portfolio standard, called the Renewable Obligation ("RO"). The goal was to create a technology neutral support system that would permit renewable electricity generators to participate as

[65] For more detail on the NFFO, see Dr Robert Gross and Phil Heptonstall, *Time to stop experimenting with UK renewable energy policy*; ICEPT Working Paper, October 2010, ICEPT/WP/2010/003, pages 8-10.

much as possible in competitive electricity markets[66]. Just like typical RPS markets in the US, the RO involved the creation of tradable certificates – renewable obligation certificates ("ROCs"), which renewable electricity generators receive and electricity suppliers must acquire to meet their annual obligation.

At the outset of the RO, one ROC was awarded for each MWh of renewable electricity. While the idea of treating different technologies differently - in the UK this was called "banding"- was discussed around the creation of the RO, it was originally rejected with the argument that it would unduly distort market forces, and that early stage technologies' demonstration projects should instead be supported through capital grants[67].

However, 'banding' was introduced after all by 2009 through the implementation of the Energy Policy Act of 2008, as it was concluded that the technology-neutral RO did not create sufficient incentives for the development of less mature technologies, at least some of which were believed to be required to meet the UK's long term renewable energy goals[68]. As a result, offshore wind received 1.5 ROCs/MWh, wave and tidal, dedicated energy crops, advanced gasification and pyrolysis, and anaerobic digestion systems receive 2 ROCs/MWh, while more established renewable technologies such as landfill and sewage gas receive less than 1 ROC /MWh. Offshore wind support was subsequently increased to 2 ROCs/MWh for projects coming online before March 2014[69].

Between the introduction of the RO in 2002 and 2010, the share of renewable energy in the UK electricity mix increased from below 3% to 7.4%[70]. This means that the RO failed to meet its original target of 10% renewable electricity production by 2010[71]. Progress was also slow when compared to the progress made in other European countries. By 2008, only two other countries covered by the 2009 EU Renewable Energy Directive – Malta and Luxemburg, had made less progress towards the 2020 targets than the UK[72].

Even before banding was introduced, the relative merits of certificate-schemes such as the RO in the UK (or state level RPS programs in the US) and fixed price schemes such as FITs were actively discussed. It was acknowledged as early as 2007 that certificate-based schemes might

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[66] Ibid, p.10.

[67] UK Department of Trade and Industry, *New & Renewable EEnergy, Prospects for the 21st Century: The Renewables Obligation Preliminary Consultation*; 2000, page 25f..

[68] UK Department of Trade and Industry, *Reform of the Renewables Obligation and Statutory Consultation on the Renewables Obligation Order 2007*, October 2006, page 11.

[69] DECC, *Digest of United Kingdom Energy Statistics 2011*, page 188.

[70] Ibid, page10; See also DECC, *Digest of United Kingdom Energy Statistics 2011*, Chart 7.4, page 193 and Chart 7.7, page 217.

[71] UK Department of Trade and Industry, *New & Renewable Energy, Prospects for the 21st Century: The Renewables Obligation Preliminary Consultation*, 2000, page 1.

[72] DECC, *Digest of United Kingdom Energy Statistics 2011*, page 195.

create more revenue risk for private investors and hence may discourage investment in at least some renewable generation technologies[73].

As of April 1, 2010, the RO was complemented by a FIT for PV and other micro-generation technologies (with capacity under 5 MW). Small projects (smaller than 50 kW) were only supported through the FIT. Projects between 50kW and 5 MW could choose between the FIT and the existing RO. The FIT consists of a two-part tariff, one for each unit of electricity generated and one for each unit of electricity exported to grid, both linked to the Retail Price Index. The PV FIT is for 25 years. Specific tariff levels are dependent on size and type of installation.[74]. At the end of October 2011, in response to the faster than expected uptake of solar PV installations under the program, the UK Government announced relatively significant cuts to the rates under this program. The proposed changes ("Comprehensive review of feed-in tariffs for solar pv") were to cut feed-in tariffs for solar with capacities below 4kW from 43p/kWh to 21p/kWh, for installations between 4 and 10kW to 16.8p/kWh and for installations below 250kW to 12.9p/kWh[75].

The Energy Bill now being in the final stages of discussion, if implemented as proposed, will create a fuller transition to FITs as the primary mechanism for renewable energy support. The RO will continue to exist through 2037, but will be closed for new projects as of 2017. Between 2017 and 2027[76], the price of a ROC will essentially be managed through the use of "headroom", i.e. an annual adjustment of the RO to keep the price of a ROC in the expected range. As of 2027, the price of a ROC will be fixed. At that point, the RO system will essentially become a fixed premium FIT (meaning that qualifying generators will receive a fixed payment on top of any market payments they receive).

The rationale for the fundamental changes not only to the renewable support system, but to other parts of electricity markets as well, is outlined as follows:

"…the market adjusted with various policy add-ons will not deliver the huge investment necessary to provide the diverse portfolio we need for a variety of reasons:

- low carbon plant such as nuclear or offshore wind typically has very high upfront capital costs and very low ongoing costs, compared with unabated fossil fuel plant such as gas;
- technologies are at very different stages of development;
- low carbon plant is price taking and more exposed to gas or carbon price volatility, compared with gas fired generation which tends to be the marginal, price setting plant,

73 See for example UKERC, *Investment in electricity generation, the role of costs, incentives and risks*, May 2007, page 4 and pages 48-49, which point specifically to the difficulty of capital intensive technologies such as wind to obtain sufficient debt, resulting in the need for balance sheet financing, which in turn makes the total project cost higher than it would be with appropriate debt leverage.

74 DECC, *Digest of United Kingdom Energy Statistics 2011*, page 197.

75 [find citation]

76 DECC, *Planning our electric future: technical update*, December 2011, page 50.

generally able to pass through any changes in gas or carbon prices to the electricity price;
- the cost of carbon is not fully reflected in the market price as it does not take into account the damage caused to the climate. This is what Lord Stern called the 'greatest market failure of all time'.
- The carbon price is also volatile and hard to predict - making long-term investment decisions more uncertain.
- The market may not bring forward enough generation to meet demand at all times, as this would require very high electricity prices at times of high demand.[77]"

In other words, the UK Government has concluded that the RO and its underlying philosophy of technology neutrality as well as a pure reliance on carbon pricing alone are not sufficient to foster the development of renewable energy at the scale needed to meet its policy goals.

The current draft operational framework for the implementation of the FIT specifically mentions the removal of revenue uncertainty related to wholesale market prices as the key reason for establishing the FIT[78]. As currently proposed, the FIT will be in the form of a Contract for Differences ("CfD") FIT. This means that a renewable energy provider will sell the energy and capacity of the renewable facility into the market, but receive an additional payment if the market price falls below a specified strike price. Similarly, if market prices rise above the same strike price, the renewable operator has to pay back the difference between the (high) market price and the strike price. It is currently expected that FITs will be available for a 15 year term[79]. The strike prices for the FIT CfDs will initially be set administratively, but the UK government is emphasizing that it intends to move towards more competitive processes for determining the strike price, for example through technology-specific competitive tender processes, as early as practical, perhaps as early as 2017, and technology neutral approaches as technologies mature[80]. At present, the Government does not plan an automatic decrease in the administratively set strike price, but rather proposes to adjust the strike price whenever there is market evidence of reduced costs. To provide regulatory certainty for investors, it currently plans to publish strike prices for the first five years of the FIT regime (2014-2018) by 2013 (any qualified project would receive the same FIT strike price over the entire 15 year period – but projects beginning in 2016 will receive a different price than projects starting in 2015)[81]. To control the quantity of renewable capacity coming on-line, the Government plans to conduct CfD allocation rounds every six months, with the opportunity to revise the strike price between rounds.

The Government is currently exploring several options for ensuring that total support payments resulting from approved CfDs do not exceed the total budget for such payments. As

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[77] DECC, Electricity market reform: policy overview; May 2012, pages 4-5.

[78] DECC, ANNEX B: FEED-IN TARIFF WITH CONTRACTS FOR DIFFERENCE: DRAFT OPERATIONAL FRAMEWORK, page 3

[79] Ibid, page 6

[80] Ibid, page 9.

[81] Ibid, page 14.

of the writing of this report, it is unclear how this will be achieved. However, it seems clear that the UK Government is worried about the prospect that at any given strike price too much capacity applies for CfDs (and if contracted, results in substantial unexpected support payments). At the same time, it appears that the UK Government is not attempting to introduce an automatic adjustment mechanism such as the one that is part of the German feed-in tariff system (with automatic annual decline rates, and additional cuts in FITs if prior year installations exceed certain thresholds).

The Carbon Price Floor

In response to the perceived problem related to the volatility of the carbon price under the EU ETS (and in particular the risk of prolonged periods of low carbon prices discouraging investment, the UK government has proposed to introduce, as of April 2013, a tax on fossil fuels used for power generation. The tax will be higher for high-carbon fuels than for lower carbon fuels and will de-factor be calibrated so that together with the price for EU emissions allowances ("EUAs"), a price floor for carbon would be established. If the EUA price is above the floor, the tax would be zero; if the EUA price is below the floor, the new tax would make up the difference. The floor will start at £16 per ton of CO2 and rise to £30/ton of CO2 by 2020 and to £70/ton of CO2 by 2030 (in real terms)[82].

As of the writing of this report, the design of the carbon price floor is still under development. There have been many comments on the proposal; at least some pointing out that it is unclear how successful the approach can be in actually accomplishing its goal of more predictable carbon floor prices, while others point to the negative competitive effect a unilateral floor price might have on UK industry.

The Green Investment Bank

On May 15, 2012, the Green Investment Bank ("GIB") was formed in the UK as a public company with initial funding of £3 billion through 2015. It will have an independent board, which will allow it to function independently from the British government, which is its sole initial shareholder. Renewable energy, in particular off-shore wind, is one of the initial focal areas for the GIB's activity[83].

The range of possible activities for the GIB includes early stage grants, equity co-investment, wholesale capital, mezzanine debt, offering to buy completed renewables assets, purchase and securitization of project finance loans, insurance products and long-term carbon price underwriting[84].

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82 See HM Revenue & Customs, *Carbon Price Floor: Further Legislative Provisions and Future Rates* and HM Treasury and HM Revenue & Customs, *Carbon price floor consultation: the Government response*, March 2011

83 See http://discuss.bis.gov.uk/enterprise-bill/files/2012/05/12-853-enterprise-regulatory-reform-bill-green-investment-bank.pdf

84 Green Investment Bank Commission, *Unlocking investment to deliver Britain's low carbon future*, 2010, page xiv.

Lessons learned from the UK programs

Several lessons can be drawn from the UK experience with renewable energy support.

First, like Massachusetts, the UK, after experiencing slow progress early in its programs, gradually moved from a technology-neutral certificates program first to a technologically differentiated certificates program and now towards a system of long-term revenue support through FITs (in contrast to the use of long-term contracting in Massachusetts). Hence, just like in Massachusetts, the UK seems to have concluded that for large scale deployment of renewable power a support system that is both technology-specific and provides stable long-term revenue support is needed.

Second and related, the early experience in the UK suggests that a conclusion was reached that auction mechanisms (i.e. competitive procurement), even if generally designed to minimize costs, may not lead to successful results when applied to fast evolving technologies. In fact, this seems to be a general lesson that also applies to other industries experiencing rapid technological change, such as telecommunications and information technologies. In these industries uncertainty about future costs is extremely high, with a wide range of possibilities depending on the speed at which technology evolves. In this context the dominant strategy for firms participating in competitive procurement processes is to bid their lowest expected cost, even if they assign a low probability to this potential outcome. If costs fall according to the bid they undertake the investment. If, on the contrary, costs fall at a slower pace than assumed in their bid, they try to renegotiate the initial agreement, which may or not work. In any case the strategy is chosen because the benefits from preventing rival companies from winning the project more than offset these additional minor costs for the company. The net result is often a delay in deployment, which is at odds with stated policy goals to accelerate deployment in an effort to reduce cost through scaling and learning.

And third, it seems to have been concluded that the involvement of public funding partners (EIB, Green Investment Bank) is critical to attract the capital flows necessary for the ambitious scaling up of renewable capacity over the next years.

V. POTENTIAL LESSONS FOR FUTURE FEDERAL RENEWABLE ENERGY POLICY

In this section, we attempt to extract from the set of case studies analyzed in this report lessons that might be useful for the development of future U.S. renewable energy support. Drawing lessons from case studies is by definition a qualitative rather than a rigorous quantitative/analytical exercise. We nonetheless believe that across the cases we analyzed certain themes of successful renewable energy support policy emerge. We summarize those below. We also assess the current state of U.S. federal policy supporting the development of renewables in light of these themes.

Subsidies versus support policies

Unless there are significant positive externalities associated with the development or renewable energy – i.e. its development has a positive impact on the overall economy and is not limited to reduced emissions and related externalities, it is theoretically preferable not to use broad tax revenues to support renewables, since this will, all else equal, make energy cheaper and hence lead to a tendency to consume more, which is at odds with any goal of reducing emissions.

The FITs in Germany (and perhaps soon in the UK) are in general already paid by electricity consumers, not tax payers, which means that any additional cost of renewables is reflected in higher electric bills, as it should be. The effect of long-term contracts above market prices has the same effect.

Some of the rebates offered for renewable energy related products, such as for solar PV installations and for various energy efficiency measures (not discussed in this report) are also paid through funds collected from electricity consumers.

Much of the financial support through development banks, but also all the Federal support programs for renewables in the US, however, are in essence financed by tax payers, not energy consumers. From an economics perspective, this could easily be changed. For example, a federal "tax" on electricity – along the lines of a federal gasoline tax – could be used to fund a "green bank" and thus support lending to renewable energy projects if lending is deemed to be the preferred approach, perhaps because public lending will attract private co-financing.

Stable Regulatory Environment and Credible Commitment to Renewable Energy

A second important theme to emerge from our case studies is the importance of a relatively stable political and regulatory environment around the development of renewable energy and other low-carbon energy sources. The success of Germany in developing renewable energy is repeatedly credited to the long-term commitment as well as its relatively stable (at least until recently) framework for renewable energy support. By contrast, while the UK has been characterized by a relatively stable commitment to fostering the development of low-carbon energy sources, its support framework has been shifting frequently, which in turn has potentially hampered the development of renewables.

Convergence Towards Long-term Price Support

A third feature emerging in essence from all four case studies is the importance of lowering risks related to the sale of products from renewable energy projects. This theme manifests itself in two ways: First, countries (and states) that provide relatively certain revenue streams for renewable projects, either through long-term contracts or FITs, have been relatively successful at attracting renewable development. This is the case for California and for Germany. On the other hand, we observe that states and countries that originally did not have similar price certainty, namely the United Kingdom and Massachusetts, have been moving towards support systems providing more revenue certainty over time. In the case of the UK, this manifests itself in the current move away from the ROCs and towards a system of FITs for renewable energy. In the case of Massachusetts, it manifests itself in the move of requiring more RPS compliance to be with the help of long-term contracts rather than relying on market sales of energy, capacity and RECs.

The importance of providing relatively stable revenue streams for renewable projects has thus been recognized both empirically and theoretically[85]. Generally, FIT systems (and by extension long-term contracts) have been shown to be more cost-effective and efficient than quota regimes. For a long explanation of why, see Ecofys etc[86]. For example, the EC, in a recent publication, states that

> *"Reviewing the relationship between project risk and instrument choice, the empirical evidence suggests that the more reliable revenue stream provided by feed in tariffs is generally more effective in driving renewable energy growth, particularly for a broad range of technologies. Quota obligations and tradable green certificates often suffer from revenue volatility and require payment of a risk premium, which appears to make them both less effective and efficient.[87]"*

In Europe, FITs have been the predominant approach, whereas long-term contracting is dominating in the United States in states where long-term revenue stability has been an explicit goal of renewable energy support. Both approaches have their advantages and disadvantages. FITs have the advantage of being relatively simple and transparent, minimizing transaction costs and allowing participating by small as well as larger companies. The downside to FITs tend to be that the same FIT applies to all projects of a given vintage and technology, independent of project specific cost differences, and that FITs in at least some countries have been subject to significant risk of ex-post change that undermines FITs ability to convey long-term price stability. Long-term contracts have the theoretical advantage that contract prices can reflect project specific costs. In particular, competitive procurements allow the selection of the least cost options among many competing proposals, all of which might get built under a FIT. Long-term contracts also likely permit better control of the total quantity of renewable energy that is supported. Experience with at least some FITs suggests that setting the level of the FIT a little too high can result in large numbers of projects coming on-line, with the result in support payments far in excess of initial estimates. Adjusting the FIT frequently before technological improvements and/or controlling explicitly for installed capacity are potential solutions to this problem, but they require relatively complex administrative procedures, which in turn are subject to criticism. Long-term contracts may also be less subject to political risk since they are typically signed with commercial counter-parties rather than guaranteed by government. In practical terms, FITs have faced legal obstacles in the United States. In particular, FITs have been ruled to be inconsistent with federal rules

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85 See for example Karlynn Cory, Toby Couture, and Claire Kreycik, *Feed--in Tariff Policy: Design, Implementation, and RPS Policy Interactions*, Technical Report, NREL/TP--6A2--45549, March 2009, which concludes that there is mounting evidence that FITs are more cost effective than certificate programs under an RPS. For a quantitative assessment of the experience in Europe, see also Commission of the European Communities, Commission Staff Working Document, The support of electricity from renewable energy sources, Accompanying document to the Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, SEC(2008) 57, 2008, page 8ff

86 See Ecofys etc.; Financing Renewable Energy in the European Energy Market; Final Report; January 2, 2011; prepared for European Commission, DG Energy; chapter 5, pp.99ff.

87 COMMISSION STAFF WORKING DOCUMENT, Review of European and national financing of renewable energy in accordance with Article 23(7) of Directive 2009/28/EC, SEC(2011) 131 final; page 6.

governing the interstate transport of electricity. On the downside, long-term contracts likely carry higher transaction costs and are less transparent than FITs.

Convergence Towards Technology Specific Support

A related feature of successful policies, at least in terms of fostering development, has been some degree of differentiation in revenue support by technology. This emerged in the UK even before the move towards FITs, by awarding more than one ROC per unit of output to certain technologies. In Massachusetts, the creation of a solar-REC program is also a manifestation of this trend. At the core of technology-specific price support lies the notion that without such differentiated support (i.e. under a carbon price only, a technology neutral RPS or technology-neutral contracting rules), more mature technologies tend to win out and in essence delay or prevent the development of less mature technologies, even if, in the long run, those technologies have the potential to produce renewable energy at lower cost.

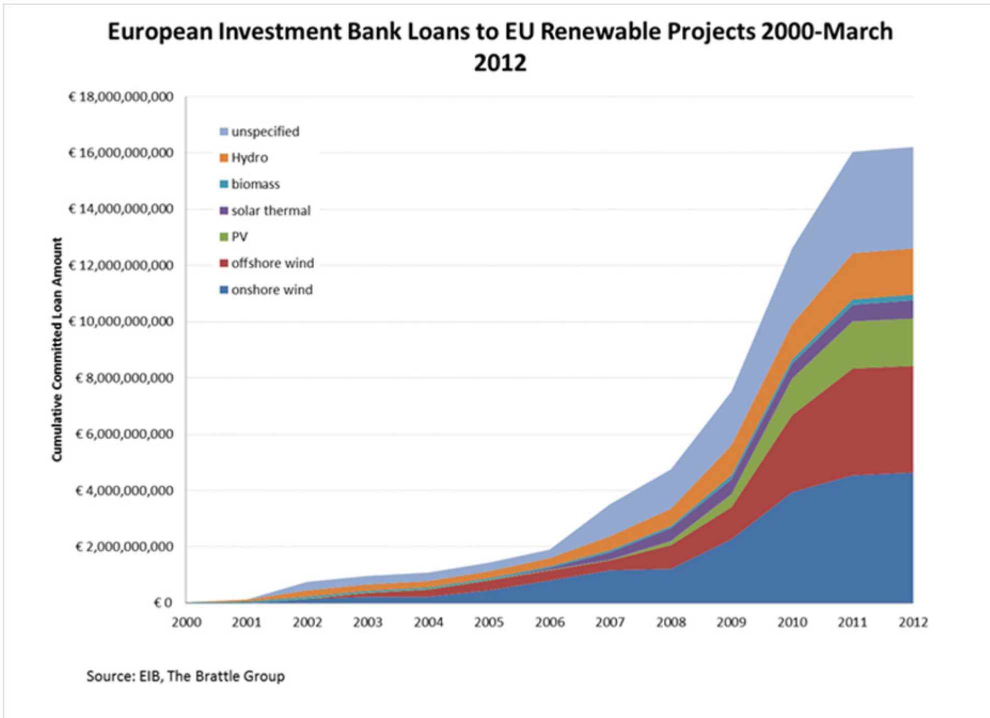
Public Financing Support to reduce investment costs

A final theme, although not as often publically discussed, is the role of public financing support for renewable energy, primarily in Europe, where a very large portion of total investment in renewable energy projects has been supported with the help of low-interest loans from institutions such as the EIB and the KfW. To our knowledge, such public financing has not played an equivalent rate at the state level in the United States, but, as we discuss above, it has been quite important at the federal level and the international experience suggests that it may be important in the future. One of the key features of what amounts to public lending in Europe is the fact that the programs themselves seem to be relatively independent of politics in that the lending happens in the context of long-term loan programs that are not subject to frequent interference by the political realm.

For example, EIB investments in renewables between 2000 and 2012 have been in excess of €16 billion (which corresponds to roughly a quarter of the €65 billion of total energy related lending over the same time period, a significant share of the rest going to upgrading transmission and distribution infrastructure)[88]. Figure 6 below shows the breakdown of EU lending by the EIB by technology and year.

[88] Derived from data on EIB lending published on the EIB website, www.eib.org

Figure 6: Lending by the EIB for Renewable Energy Projects



Source: EIB, The Brattle Group

VI. CONCLUSIONS

In this paper, we summarize the main theoretical arguments for renewable energy support, based on various environmental, knowledge and related externalities. We find that the theoretical argument for some form of support for renewable energy is relatively strong.

However, how such support is provided varies widely and likely has a significant impact on both efficacy and efficiency, i.e. on the success of supporting the development of renewable energy and on the cost of doing so.

We examined two domestic (California and Massachusetts) and two European (Germany and the United Kingdom) case studies to extract key elements of renewable energy support that appear to impact the success of such efforts. Four such elements emerge from our analysis:

- Stable political and regulatory environment towards renewable energies.
- Long-term revenue stability.
- Technology-specific support.
- Complementary support through independent public infrastructure banks, development banks or related agencies.

Given these themes, current federal renewable support approaches leave significant room for improvement. Moving support in these directions would likely improve the efficacy of federal programs and lower the cost to tax and rate payers. Both could increase the acceptability and political popularity of the resulting programs. The success of countries like Germany or states like California in developing renewables at a very rapid pace has helped lower the costs of various kinds of renewables, making it less costly for the United States to further develop renewables. It has also illustrated that with a stable policy framework drawing appropriate lessons from the multitude of approaches to support renewable energy it is possible to significantly scale up the development and deployment of renewable energy in the United States.

Abbreviations

AB 32	Assembly Bill 32: California Global Warming Solutions Act
ACP	Alternative Compliance Payment
ARRA	American Recovery and Reinvestment Act
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CAA	Clean Air Act
CEC	California Energy Commission
CfD	Contract for Differences
CLEAN	Clean Local Energy Accessible Now
CPUC	California Public Utilities Commission
CSI	California Solar Initiative
DECC	Department of Energy and Climate Change
DOE	U.S. Department of Energy
DOER	Massachusetts Department of Energy Resources
EEG	Erneuerbare Energien Gesetz
EIB	European Investment Bank
ERP	Emerging Renewables Program
EUA	EU emissions allowance
EU-ETS	European Union Emissions Trading Scheme
FERC	Federal Energy Regulatory Commission
FIT	Feed-in Tariff
GCA	Green Communities Act
GHG	Greenhouse Gases
GIB	Green Investment Bank
ITC	Investment Tax Credit
KfW	Kreditanstalt für Wiederaufbau
MAP	Market Incentive Program
MGPP	Massachusetts Green Power Partnership
MPR	Market Price Referent
MTC	Massachusetts Technology Collaborative
NFFO	Non Fossil Fuel Obligation
PTC	Production Tax Credit
PURPA	Public Utility Regulatory Policy Act
QF	Qualifying facility
RAM	Renewable Auction Mechanism
REC	Renewable Energy Certificate
RFO	Requests for Offers
RGGI	Regional Greenhouse Gas Initiative
RO	Renewables Obligation
ROC	Renewable Obligation Certificate
RPS	Renewable Portfolio Standard
StrEG	Stromeinspeisungsgesetz

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